INSTRUCTION MANUAL

COMPLEX IMPEDANCE-ADMITTANCE METER

MODEL 100B

with

IMPEDOMETER-ADMITTOMETER PLUG-IN

MODEL 100PA-1001A

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SECTION I

GENERAL INFORMATION

1-1 INTRODUCTION

1-2 The Model 100B Complex Impedance-Admittance Meter (CIAM-100B) is a portable, completely transistorized instrument which measures vector impedance, vector admittance, capacitance and inductance rapidly, directly and accurately. (See figure 1-1.)

1-3 The Complex Impedance-Admittance Meter provides direct and accurate meter readings for either equivalent series resistance and reactance, or equivalent parallel conductance and susceptance. It covers a broad frequency range from 100 cps to 200 kc, and eliminates point-by-point balancing required in bridge systems. The unit provides approximately 1 volt d-c outputs for X-Y recorders, oscilloscopes or other recording instruments.

1-4 The Complex Impedance-Admittance Meter utilizes plug-in circuits throughout. The standard unit is supplied with Impedometer-Admittometer Plug-in Model 100-PA-1001 to provide a wide range of impedance and admittance measurements. Other plug-in modules can be provided for special application. (See Appendix C for operation of Model 100-PA-1001A Plug-in).

1-5 CAPABILITIES

1-6 With an unknown impedance connected to the panel terminals, at any frequency in the range this instrument provides a direct reading of impedance or admittance. In the impedance measuring mode, two precision mirror scale meters provide direct readings of R and ±X (without sign ambiguity) where $Z = R \pm jX$. In the admittance measuring mode, the same meters read directly G and ±B where $1/Z = G \pm jB$.

1-7 Since the susceptance of a capacitor is directly proportional to capacitance, at predetermined frequencies, the capacitance may be read directly on the susceptance meter. At a frequency of 159 kc, for example, the susceptance meter reads directly in picofarads. Similarly, the reactance meter can be used to read inductance directly. At 159 kc, this meter reads directly in microhenries.

1-8 In addition to providing direct meter readings, this instrument may also be used with X-Y recorders or oscilloscopes, as well as with strip chart recorders in order to obtain continuous locus curves in the complex impedance plane, in the complex admittance plane, or as a function of frequency. In the accompanying photograph (figure 1-2) is shown an

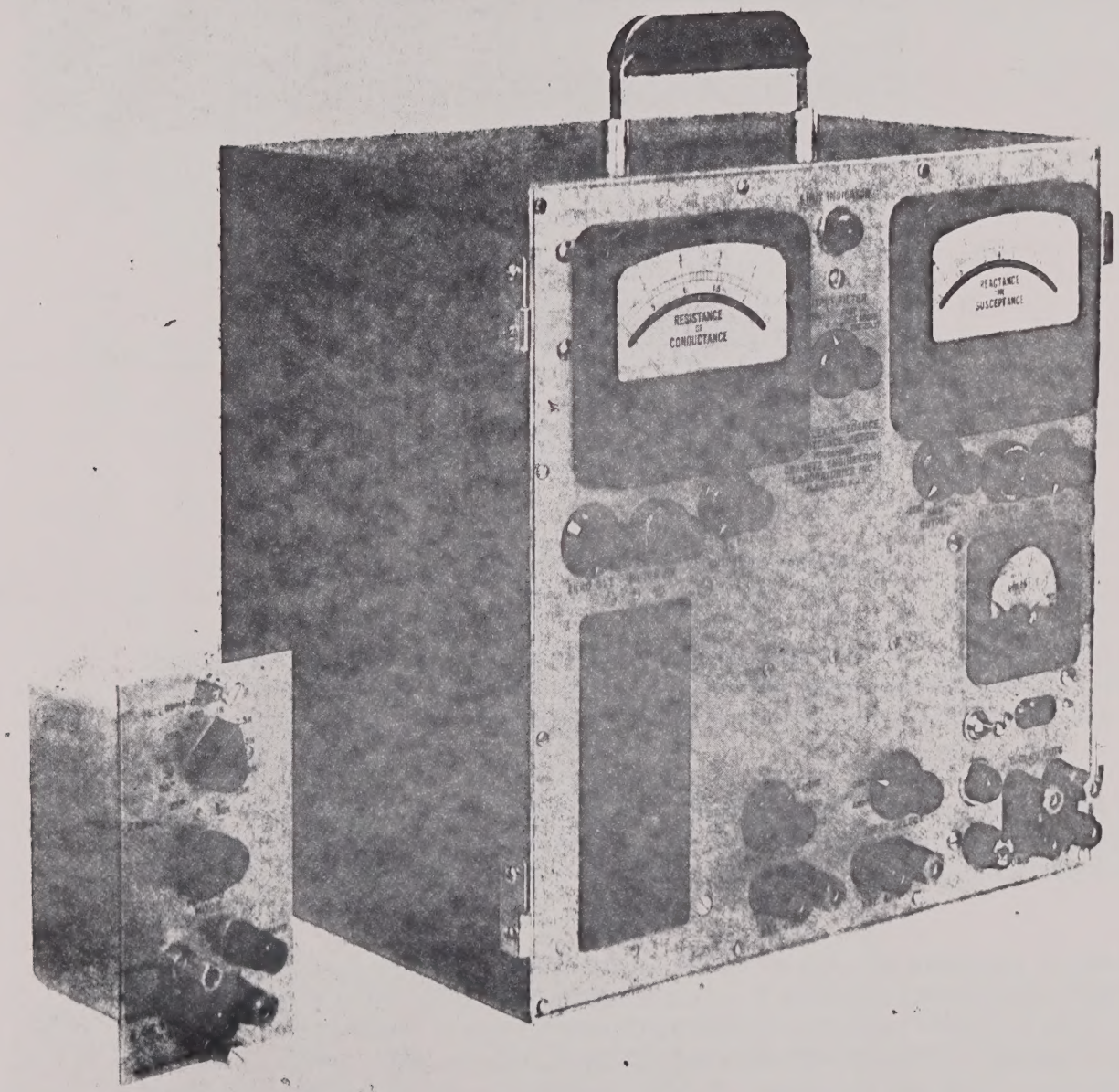


Figure 1-1. Complex Impedance-Admittance Meter Model 100B
and
Impedometer-Admittometer Plug-in Model 100-PA-1001

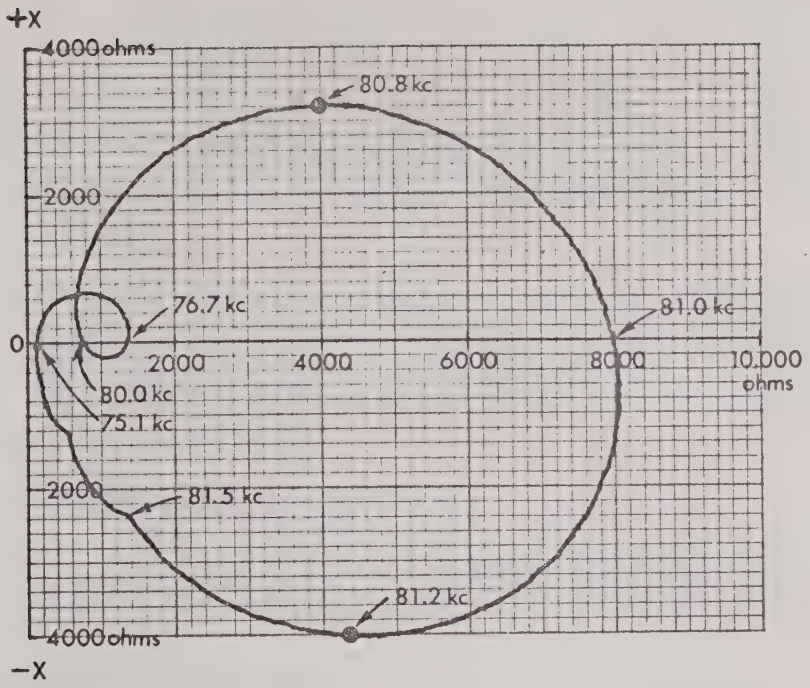


Figure 1-2. Plotted Impedance Plane Locus

impedance plane locus plotted using Electro-Instruments, Inc. model 500 X-Y Recorder. This was taken on a lead zirconate-lead titanate disc, and illustrates the presence of a secondary resonance in addition to the principal mode.

1-9 The model 100B Complex Impedance-Admittance Meter is based on the use of an impedometer-admittometer circuit in conjunction with sine and cosine resolvers. This system avoids the point-by-point balancing required by bridge systems.

1-10 For measuring impedance the internal power oscillator produces a constant current in the unknown impedance at any selected frequency. The amplitude of current is set by the range switch position, which is calibrated in ohms. The voltage developed across the unknown impedance is amplified and fed to two resolvers. The d-c output of the first resolver is proportional to the product of voltage across the unknown and the cosine of the angle between current and the voltage developed across the unknown. Hence the output is proportional to the in-phase component of unknown impedance. Similarly, the output of the second resolver is proportional to the quadrature, or reactive, component of impedance. The outputs are amplified and connected to precision panel meters, as well as to external recorder terminals through low output impedance circuits.

1-11 For measuring admittance, a constant voltage is placed across the unknown at any preselected frequency. The current through the unknown is measured by means of voltage developed across a small range-selected resistor placed in series with the unknown. This voltage is proportional to unknown admittance, and its phase angle relative to the input voltage is equal to the phase angle of the unknown admittance. This voltage is amplified and fed to the two resolvers as in the impedance case. Now, however, the resolver outputs are proportional to equivalent parallel conductance and susceptance of the unknown.

1-12 In both impedance and admittance measurements, the full scale meter readings are initially precalibrated by the use of a precision transfer standard placed in the impedometer or admittometer location. In this manner, errors are avoided which might otherwise come about through typical voltage or current measurements.

1-13 TECHNICAL CHARACTERISTICS

The operating characteristics and specifications of the Complex Impedance-Admittance Meter are listed in table 1-1. See Bulletin 100 in rear of manual.

1-14 ACCESSORIES AVAILABLE

The Complex Impedance-Admittance Meter is provided with a power cable, a 3- to 2-prong power cord adapter and a test adapter. The test adapter can be inserted between any internal plug-in module and the main chassis for exposing the plug-in terminal connections to facilitate troubleshooting. The test adapter is mounted on the rear of the main chassis inside the carrying case.

1-15 INSTALLATION

The instrument is shipped ready for operation. Special instructions for applying power are listed below:

a. Connect the instrument into a 115-volt 60 cps source.

b. The instrument must be grounded at the ground terminal (located on plug-in section) or through the power cable, but not at both terminals.

CAUTION

DO NOT APPLY D-C VOLTAGE
ACROSS ANY EXPOSED TERMINALS
OF THIS INSTRUMENT.

Table 1-1. Specifications for Model 100B

Impedance Ranges (Full Scale R&X)

10, 25, 50, 100, 250, 500, 1K, 2.5K, 5K, 10K, 25K, 50K ohms (Can also measure 10 microhenries full scale to 50 henries full scale, depending on frequency. Higher ranges of impedance possible using admittance mode)

Admittance Ranges (Full Scale G&B)

10, 25, 50, 100, 250, 500, 1K, 2.5K, 10K, 25K, 50K micrombos (can measure 10 mmfd full scale to 50 mfd full scale, depending on frequency)

Front Panel Plug-In Module

Standard plug-in module (Model 100-PA-1001) covers ranges shown. Special modules available for special applications.

Frequency Range

100 cps to 200 kcps

Accuracy

(1) Basic Instrument Accuracy
Better than ±2% full scale vector amplitude accuracy: better than ±2-1/2° vector phase accuracy from 100 cps to 150 kcps; better than 5° phase accuracy to 200 kcps.

(2) Accuracy Limitations Imposed by Impedometer-Admittometer Input Circuits of Standard Plug-in.

(a) Vector amplitude: Better than ±2% full scale up to 100 kcps for ranges of 10K or less. Accuracy decreases with increased frequencies and increased ranges to a limit of ±10% full scale at 200 kcps on 50, 000 scale.

(b) Vector Phase: Better than ±2-1/2° up to 80 kcps for ranges of 10K or less. Accuracy decreases with increased frequencies and increased ranges. At 150 kcps and 25K, the phase error is less than 16°.

Table 1-1. Specifications for Model 100B (cont)

Voltage Across Unknown

Y Measurement - 3 volts rms
Z Measurement - less than 30 mv rms

Unknown Terminals

Impedance - 3 terminals, Low (gnd), High, and Guard

Admittance - 3 terminals, Low (connected to ground through power oscillator output), High and Guard.

Calibration Reference

Internal precision transfer standard

Output Filters (Each Output)

With Panel Switch in NORMAL, Rise time (0-90%)-approx. 85 ms
With Panel Switch in FAST, Rise time approx. 30 ms

Data Presentation

Panel Meters: Two 4 inch precision mirror scale meters for direct reading of R and X or G and B. Quadrature meter indicates sign of quadrature.

Output Terminals: Two sets of output terminals, each producing 0.8 volt d.c. full scale minimum for X-Y recorder, oscilloscope or strip chart recorder.

Output Scaler

Front panel output switches provide independent scaling of X and Y outputs of 0, 50% and 100% of full scale for convenience in setting up X-Y recorder.

Power Emitter Follower

(1) Output impedance of E.F.-approx. 2 ohms

(2) Load impedance limit-will drive loads as low as 200 ohms. For measurements of admittances greater than 5000 micromhos, external oscillator and amplifier must be used. Front panel jacks provided for external oscillator and amplifier.

(3) Output level-3 volts rms (indicated on AC expanded scale voltmeter)

Input Power

105-125 volts. 60 cps, 25 watts max (Electrical circuit grounded through third wire of three wire power cable.)

Mechanical

Entire unit self contained in walnut carrying case 14" x 14" x 12" max. Carrying weight - 25 pounds maximum.

Serial Numbers

Serial numbers are assigned to the main assembly and to each plug-in module. The main assembly serial number appears internally on the rear panel and can be seen by removing the Impedometer-Admittometer plug-in. Serial numbers for all modules are printed on the outside of each module.

The following serial numbers apply to this instrument:

Main Assembly B100,035	Serial No._____
D-C Regulator B100,038	Serial No._____
90° Phase Shift Network B100,037	Serial No._____
Power Emitter Follower B100,036	Serial No._____
Squaring Amplifiers B100,039	Serial No._____
Z-Y Amplifier and Limit Relay	Serial No._____
Quadrature Resolver B100,040 B100,609	Serial No._____
In-phase Resolver B100,609	Serial No._____
Impedometer-Admittometer Plug-in Mod. 100PA100__	Serial No._____

SECTION II

OPERATION

2-1 FUNCTIONS OF CONTROLS, INDICATORS AND TERMINALS

Table 2-1 lists the functions of controls, indicators and terminals for the Complex Impedance-Admittance Meter Model 100B with Model 100-PA-1001 plug-in module. Refer to figure 2-1 for the identification of all controls, indicators and terminals.

Table 2-1. Functions of Controls, Indicators and Terminals

INDEX NO.	CONTROL, INDICATOR OR TERMINAL	FUNCTION
9	"on-off" switch	Applies main power.
10	115-Volt 60-cps A-C power receptacle	Three-wire single phase A-C input (includes one ground terminal).
12	1/4 Ampere Slo-Blo fuse	Buss AGX-1/4 AMP for A-C input circuit.
13	Indicator (red)	Indicates application of 115-volt 60-cps power.
16	EXT. OSC. Two 5-way binding terminals (black and red)	For connection of external oscillator for all impedance ranges and admittance ranges up to and including 5000 micromhos.
15	EXT. AMP. Two 5-way binding terminals (black and red)	For connection of external amplifier. External amplifier must be used for measuring admittances greater than 5000 micromhos.
14	INPUT SELECT switch OSC. - AMP.	A 2-position switch which selects external oscillator or amplifier input.
17	FREQ. RANGE switch 0.1 - 2KC 1 - 20KC 10 - 200KC	Selects operating frequency range of the instrument.

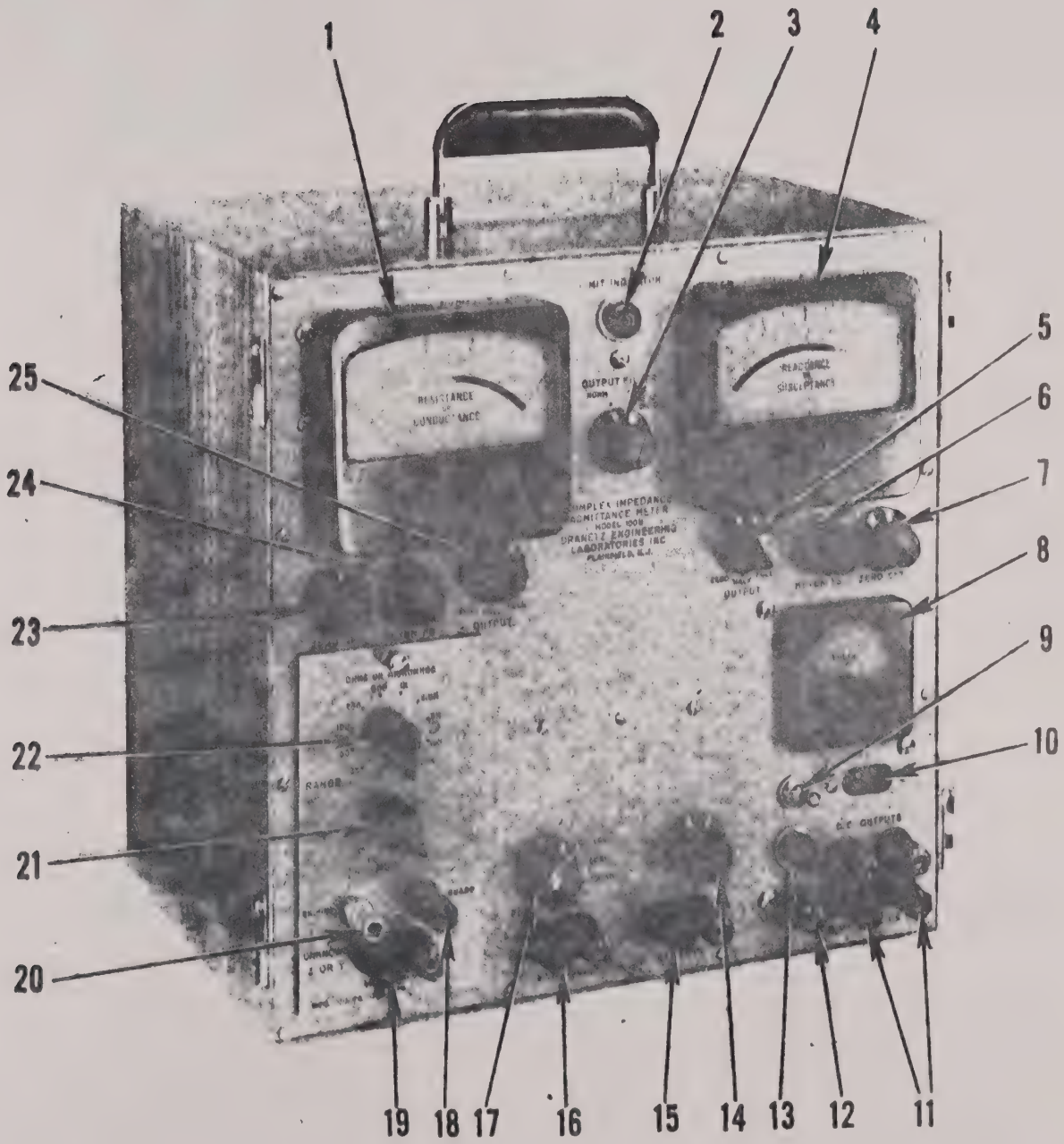


Figure 2-1. Complex Impedance-Admittance Meter Model 100B, Front Panel

Table 2-1. Functions of Controls, Indicators and Terminals (cont)

INDEX NO.	CONTROL, INDICATOR OR TERMINAL	FUNCTION
11	D. C. OUTPUTS Two pairs of 5-way terminals (black and red)	One pair of terminals for D-C output voltage proportional to resistance or conductance (R or G respectively). One pair of terminals for D-C output voltage proportional to reactance or susceptance (X or B respectively). NOTE For connection to external recording instruments, black terminals are internally connected to circuit ground; red is high side.
8	A-C expanded scale voltmeter (rms)	Monitors voltage level of signal applied to impedometer-admittometer network. For all measurements, signal voltage should be set to 3 volts rms and maintained throughout precalibration and operational measurements. CAUTION Waveform of input signal should be free of harmonic distortion. Do not apply voltages in excess of 3.5 volts rms.
1	RESISTANCE or CONDUCTANCE meter	A 4-inch mirror scale linear meter which reads resistance or conductance. Meter scale corresponds to RANGE switch positions.
4	REACTANCE or SUSCEPTANCE meter	A 4-inch mirror scale linear meter which reads reactance or susceptance. Meter scale corresponds to RANGE switch positions.
23 7	ZERO SET controls (resistance or conductance) (reactance or susceptance)	One control each for resistance or conductance and reactance or susceptance for adjustment of meter zero indications with mode switch on Calibrate - O. (Simultaneously adjusts zero level D-C outputs.)
6 24	METER FS controls (reactance or susceptance) (resistance or conductance)	Locking control for adjustment of meter full scale readings. These controls adjust the sensitivities of the meters and do not effect the D-C output levels.

Table 2-1. Functions of Controls, Indicators and Terminals (cont)

INDEX NO.	CONTROL, INDICATOR OR TERMINAL	FUNCTION
25 5	OUTPUT switches ZERO - HALF - FULL (resistance or conductance) (reactance or susceptance)	One for each of the two D-C outputs. Attenuates the output by zero (FULL), 50% (HALF) or 100% (ZERO position).
3	OUTPUT FILTER switch NORM. - FAST (USE ABOVE 2KC ONLY)	In FAST position, the output filter is changed to provide a rise time of 30 milliseconds. In addition, high-pass filters are inserted in the signal circuits throughout the instrument to attenuate frequencies below 2 kilocycles. NORM position contains a low-pass filter with a rise time of 85 milliseconds. The filter is located in the output of each of the resolver circuits.
2	LIMIT INDICATOR	Indicates when the unknown impedance or admittance is substantially greater than the full scale setting. Simultaneously with the turning on of the indicator light, an internal relay shunts the meters and the D-C output terminals to zero. NOTE During operation, proceed to higher full scale of RANGE switch until indicator lamp does not light.
Located on plug-in Model 100-PA-1001		
19	UNKNOWN Z OR Y terminals LOW (black) - HIGH (red)	Five-way terminals for connection to device being measured. Note: For impedance measurement, black is ground and red is high side. For admittance measurement, both terminals are ungrounded. (See paragraph 2-6 for use.)
18	GUARD terminal	A special connection for a driven shield with minimum capacitive loading of the unknown device.

Table 2-1. Functions of Controls, Indicators and Terminals (cont)

INDEX NO.	CONTROL, INDICATOR OR TERMINAL	FUNCTION
Located on plug-in Model 100-PA-1001		
20	GROUND terminal	Alternate ground connection. CAUTION Operator should use either this GROUND terminal or alternate ground through power cable but not both simultaneously. This is done to avoid ground loops.
21	MODE 4-position switch Y - FS - O - Z	Selects precalibration and operation modes: Y - Admittance. FS and O - Adjustment for calibration of zero and full scale positions only. Precalibration holds for any amplitude range of impedance or admittance. Z - Impedance.
22	RANGE switch OHMS OR MICROMHOS 12 positions: 10 - 25 - 50 - 100 - 250 - 500 - 1K - 2.5K - 5K - 10K - 25K - 50K	Presets full-scale ranges for admittance and impedance. Impedance is indicated in series resistance or reactance. Admittance is indicated in parallel conductance and susceptance.

2-2 OPERATING PROCEDURE

CAUTION

DO NOT APPLY D-C VOLTAGES TO
ANY TERMINAL ON THE FRONT PANEL.

2-3 Presetting and Connection Procedure

a. Plug the power cord into a 3-terminal 115 volt 60 cps outlet. The instrument can be grounded by the third wire of the power cable; however, the instrument should be grounded at only one point. If the ground terminal on the plug-in unit is to be used as the ground, the ground on the power cable should NOT be used; in this case, use a 3-pin-to-2-pin adapter in plugging the power cable into an appropriate outlet.

NOTE

An internal fuse is provided in the event that a voltage is inadverdently applied between these two ground points. If during operation, it is suspected that the third wire of the power cable is open-circuited and does not provide a ground, this fuse should be checked. (The fuse (F2) is located inside the instrument on the rear panel.)

b. Connect an external oscillator having maximum of 3.5 volts rms output to EXT. OSC. terminals. If admittance measurements are to be made on an unknown having an admittance of more than 5000 micromhos, connect the output of the external oscillator to the input of an external power amplifier and connect the output of the power amplifier to EXT. AMP. terminals.

CAUTION

MAKE SURE THAT THE POWER AMPLIFIER DOES NOT APPLY MORE THAN 3.5 VOLTS RMS TO THIS INSTRUMENT. EXCESSIVE VOLTAGE MAY BLOW A FUSE (F3) LOCATED IN THE REAR OF THE INSTRUMENT AND/OR CAUSE PERMANENT DAMAGES.

The power amplifier must have sufficiently low output impedance so that frequency dependence of the unknown impedance will not change the output level of the power amplifier.

CAUTION

DO NOT CONNECT D-C VOLTAGE
TO THESE TERMINALS.

c. Set controls as follows:

(1) RANGE switch to 50K.
(2) MODE switch to calibrate 0 position.
(3) FILTER switch to NORMAL.
(4) FREQUENCY switch to desired frequency range.
(5) INPUT SELECT switch to either EXT. OSC. or EXT. AMP., depending on intended use.
(6) Both OUTPUT switches to ZERO.
(7) Set external oscillator and/or amplifier output gain controls for zero output.
(8) Set oscillator control to a frequency in the vicinity of intended measurements.

2-4 System Turn-On Procedure

a. Snap front panel toggle of CIAM-100B to right, at which time the red pilot lamp will light.

b. Turn on power oscillator (and power amplifier if used) and adjust the gain control until the A-C Voltmeter on the CIAM-100B reads precisely 3 volts rms.

NOTE

While the system is ready for use IMMEDIATELY after application of power, a warm-up period of 1/2 hour is recommended to stabilize zener diodes used in the equipment. The equipment may be left ON continuously. Since the internal gating circuits require an input sine wave for control, the external oscillator should be turned on whenever the CIAM is turned on. Otherwise, loss of switching control may result in a very low frequency oscillation of output voltage, as evidenced by motion of the panel meters.

2-5 Precalibration Procedure

a. Check to insure that input signal level is precisely 3 volts rms and remains at this level throughout precalibration and measurement.

b. With MODE switch in calibrate 0 position, adjust left ZERO SET control until pointer on RESISTANCE or CONDUCTANCE meter reads ZERO (left end of scale).

c. Repeat b. above with right ZERO SET control until REACTANCE or SUSCEPTANCE meter reads at center of scale.

d. Turn MODE switch to calibrate FS.

e. Adjust left METER FS control until pointer on RESISTANCE or CONDUCTANCE meter reads at the full-scale level (right end of scale).

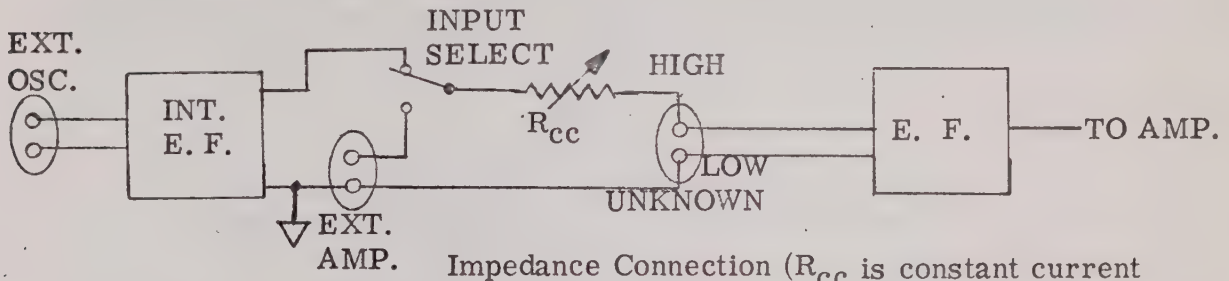
f. Adjust right METER FS control until pointer on REACTANCE or SUSCEPTANCE meter reads at negative full scale (left end of scale).

NOTE

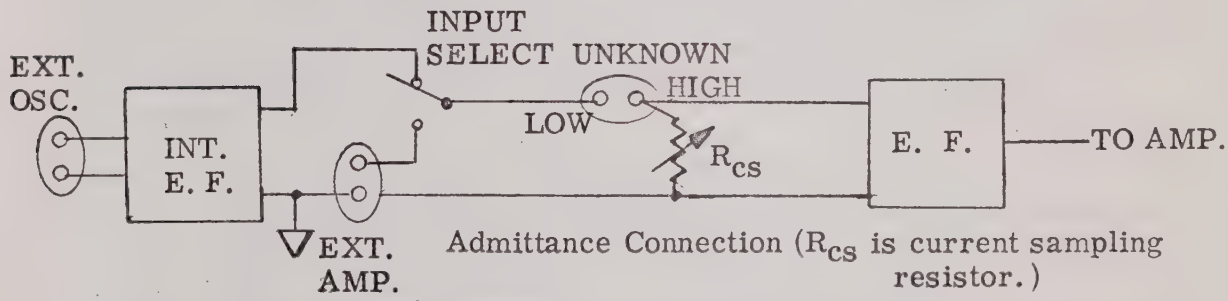
The METER FS controls merely adjust the meter sensitivities and do not change the values of d-c outputs.

g. The instrument is now ready for operation.

a. Connect the unknown impedance to the UNKNOWN terminals, observing LOW and HIGH terminal designations. The following diagrams show how connections are made internally (in the standard Impedometer-Admittometer plug-in module).



Impedance Connection (R_{cc} is constant current resistor.)



Admittance Connection (R_{cs} is current sampling resistor.)

In the impedance connection (MODE switch in Z), the unknown is grounded, the LOW terminal of the UNKNOWN pair being the ground terminal. In the admittance connection, the unknown is ungrounded. Note that the LOW terminal is actually connected to the high side of the signal source. This has been done because the source impedance of the internal emitter-follower (approximately 2 ohms when the load is above 200 ohms) or an external amplifier, will always be low while the resistance R_{cs} may be as high as 1000 ohms (for the 10-micromho scale). Thus, the LOW terminal designation refers to "low impedance to ground" rather than low voltage as might otherwise be interpreted.

CAUTION

Since high voltage may damage the semiconductor circuits, two precautions should be taken before connection of an unknown. First, if the unknown has a d-c path from a d-c voltage source to the measurement terminals, the d-c path should be blocked by a capacitor, transformer, or other means. Second, in the case of dielectric components or piezoelectric devices, which might retain an electrical charge, such a unit should be shorted momentarily before connection to this instrument. Particular attention should be given to the generation of charge during polarization relaxation (soon after polarizing) or due to pyroelectric effects.

2-6 Measurement (cont)

b. Turn the MODE switch to the Y (for admittance) or Z (for impedance) to operate. With the MODE switch in the Y position, the meters read directly in equivalent parallel conductance and susceptance. In the Z position, the meters read in equivalent series resistance and reactance. The quadrature component meter indicates the sign of the component.

NOTE

The resistance meter may be used to read negative resistance by displacing the pointer during the calibrate 0 operation above.

c. Scan the frequency range by means of the variable frequency oscillator noting whether the RANGE switch is set properly (at 50K) or at too high a position. Set the RANGE switch to the best position (noting that the LIMIT INDICATOR lamp will light if the meters read off scale by a substantial amount).

NOTE

If the LIMIT INDICATOR lamp lights, check the following:
(a) If the MODE switch is in Z position, the light may indicate an open circuit in the "unknown".
(b) With the MODE switch in the Y position, the light may indicate a short circuit in the "unknown".
(c) With the MODE switch in either position, it may indicate the presence of 60 cps or other unwanted signal across the input.

If the LIMIT INDICATOR lamp remains on for all ranges, check using an oscilloscope from the HIGH unknown terminal to ground. If 60 cps signal is present, shield the cable to the "unknown" and connect the shield to the GUARD terminal. If the frequency of interest is above 2 KC, turn the FILTER switch to FAST position.

d. Quickly check the precalibration at a frequency in the vicinity of interest.

e. Set the oscillator to the frequencies of interest and at each frequency, read the two components of impedance or admittance, checking to insure that the input voltage level is held constant at each frequency.

2-7 Use of External Recorder or Indicators

a. For obtaining impedance or admittance plane plots, utilize an oscilloscope or plotter having provision for d-c inputs on both the horizontal and vertical axes. On both axes, the sensitivities should be variable, being at least full scale for an input of 0.8 volts dc.

CAUTION

Do not connect any device which has d-c voltage present on its input terminals.

b. Connect the horizontal axis input of the indicator to the R or G output terminals of the CIAM-100B and the vertical axis input of the indicator to the X or B terminals, observing that the black output terminals are grounded.

NOTE

When using an external recording instrument with the CIAM-100B, the circuits of the recorder are grounded through the output terminal of the CIAM-100B. DO NOT CONNECT OTHER GROUNDS TO THESE CIRCUITS.

c. Determine the desired graph size and locate the desired positions of horizontal and vertical origins and full scales.

d. Turn on the recording instrument.

e. On the CIAM-100B, turn both OUTPUT switches to FULL.

f. Turn the MODE switch to calibrate 0.

g. Check to see if both panel meters read zero. If not readjust ZERO SET controls as necessary.

h. Adjust the zeroing controls on the external recording instrument (oscilloscope or recorder) until the dot or pen appears at the intersection of the horizontal and vertical axis.

i. On the CIAM-100B, turn the MODE switch to calibrate FS position.

j. Adjust the horizontal and vertical gains of the external indicating instrument to full scale on the horizontal axis and negative full scale on the vertical axis.
(NOTE: For set-up convenience, the two d-c outputs of the CIAM-100B may be switched independently to ZERO, HALF or FULL scale by use of the OUTPUT switches.

2-7 Use of External Recorder or Indicators (cont)

k. Switch the MODE switch on the CIAM-100B to either Z or Y.

l. If a pen recorder is used, do not allow the pen to engage the paper until the set-up procedure is completed and the system is ready for actual recording.

m. Engage the pen and scan the frequency slowly through the band of interest, recording desired pattern.

n. If a pen recorder is used, disengage the pen from the paper immediately after drawing the continuous curve. The curve may be labeled at specific frequencies by setting frequency to values of interest after the curve is drawn, and with pen "hovering" above the paper.

o. For impedances (or admittances) having one component much larger than the other, the appropriate zero control on the recorder may be adjusted for zero offset, then both gains increased to expand the tracing. This can also be accomplished by setting up the recorder full scales using the CIAM-100B OUTPUT switches in the HALF position. After offsetting the appropriate zero of the recorder, these OUTPUT switches may be turned to the FULL position to double the output voltage. In both examples described above, the panel meters will read directly so that the extent of zero shift is known at all times.

p. After measurement of an unknown, it is recommended that the MODE switch be turned to calibrate 0 and the OUTPUT switches turned to ZERO. If the MODE switch is in the Z position when the unknown is removed, the LIMIT INDICATOR will light, and a relay will short out the meters and the D-C OUTPUT terminals.

SECTION III

PRINCIPLES OF OPERATION

3-1 COMPLEX IMPEDANCE-ADMITTANCE METER, FUNCTIONAL DISCUSSION

3-2 A block diagram describing the operating principles of the Complex Impedance-Admittance Meter is shown in figure 3-1.

3-3 A sine wave of 3 volts rms from an external oscillator or amplifier is impressed on the input of the Impedometer-Admittometer plug-in module, where it is distributed directly to three points (1) directly into the Impedometer-Admittometer circuits, (2) back out to a squaring amplifier, and (3) back out to a 90° phase shift network.

The signal within the plug-in module in conjunction with internal circuitry, results in a plug-in output voltage having an amplitude proportional to either impedance or admittance of the unknown, and having a phase shift equal to the phase of the unknown impedance or admittance. The explanation of how this is accomplished is described in another section. This signal is amplified to a level of approximately 1 volt rms corresponding to any full scale of impedance and/or admittance. Thus the output of the Z-Y amplifier is a sine wave having amplitude and phase corresponding to the amplitude and phase of the unknown being measured.

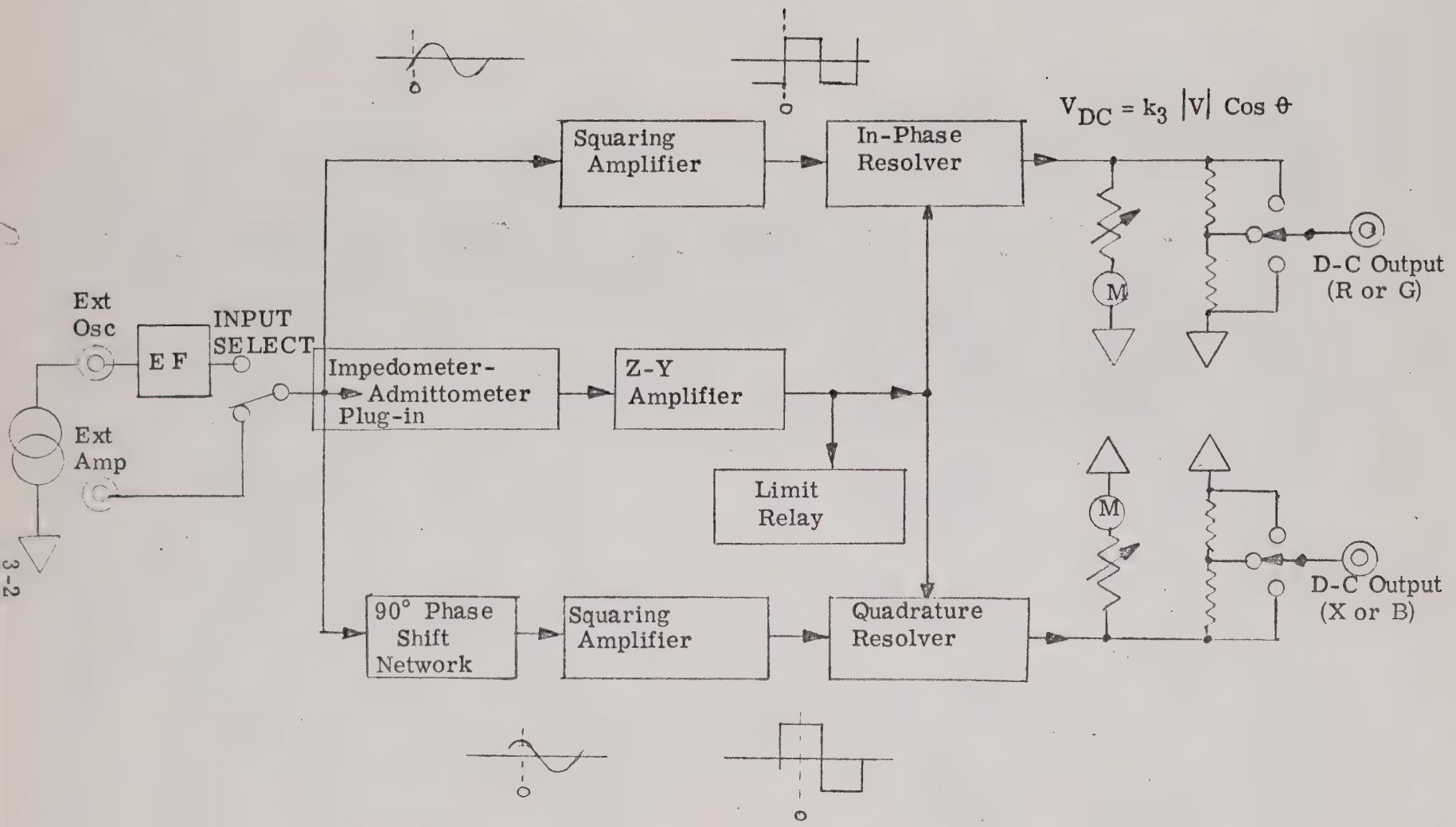
The 3-volt signals coming back out of the Impedometer-Admittometer plug-in module are used for phase reference. One signal is applied to a squaring amplifier, producing a square wave having the same zero crossing times as the original input sine wave. The second signal is applied to a 90° phase shift network, and then to a squaring amplifier which produces a square wave having zero crossings 90° out of phase with those of the original sine wave.

The resolvers are basically electronic switches and integrating circuits. The switches are held "on" during the positive portion of the square wave, allowing the signal from the amplifier to pass during this time. During the negative square wave voltage, the switches are turned off. Typical outputs from the switches are shown in figure 3-2.

The average value of a d-c output is zero when the signal and square wave are 90° out of phase and is a maximum positive when the two voltages are in phase and a maximum negative when the voltages are 180° out of phase. It can be shown that the average d-c output is given by

$$V_{dc} = A|V|\cos\gamma$$

where $|V|$ is the amplitude of sine wave into the switch, and
γ is the angle between zero cross-over of the sine and square waves.



For Impedometer, $V = k_1 Z = k_1 |Z| \angle \theta_Z$

For Admittometer, $V = k_2 Y = k_2 |Y| \angle \theta_Y$

Figure 3-1. Complex Impedance-Admittance Meter, Block Diagram

The in-phase resolver is switched by the square wave formed directly from the reference 3-volt signal. Thus, the d-c voltage output of this resolver is proportional to the in-phase component of voltage output of the impedometer-admittometer circuits.

The quadrature resolver is switched by a square wave which has been shifted 90° in phase from the reference. Thus, the d-c output is proportional to the quadrature component of voltage output of the impedometer-admittometer circuits. It should be noted that the d-c outputs may be both negative and positive; hence, the equipment may measure negative impedances or admittances.

The d-c outputs are connected to two meters having front panel sensitivity adjustments. The first meter provides a direct reading of resistance or conductance; the second reads directly in reactance or susceptance. Output terminals, connected through 3-position switches are provided for connection to recording or other indicating instruments. The output switches attenuate each of the outputs for ease in setting up external recorders.

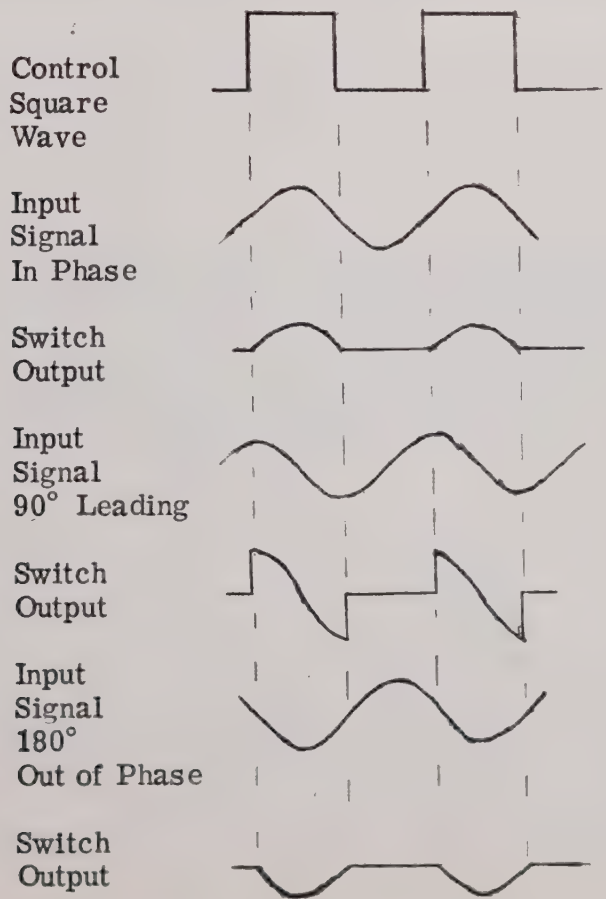


Figure 3-2. Typical Input Signal and Output Waveforms

3-4 STANDARD IMPEDOMETER-ADMITTOMETER PLUG-IN MODEL 100-PA-1001

3-5 The Model 100B Complex Impedance-Admittance Meter is provided with a standard plug-in module for both impedance and admittance measurements. Internal wiring of the system includes a number of links and special wiring to the plug-in adapter for accommodating other special plug-in units. The standard plug-in module performs three functions as shown in the schematic diagrams (figures 3-3, 3-4, 3-5, 3-6 and 3-7.

3-6 Precalibrate Function

a. Calibrate Zero

With the MODE switch in the calibrate 0 position, zero signal voltage is applied to the self-contained emitter follower and hence to the resolvers. This provides a reference for zero d-c adjustment of the two resolver units.

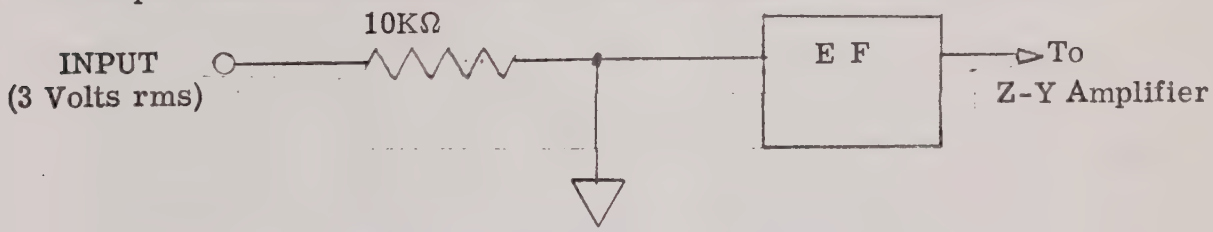


Figure 3-3. Calibrate Zero, Schematic Diagram

b. Calibrate FS

With the MODE switch in the calibrate FS position, the input signal is attenuated by precisely 100, and the output voltage is fed to both in-phase and quadrature resolvers (the 90° phase shift network is removed) to provide full scale indications. Since an attenuation of 100 corresponds to any full scale output, the meter and external indicator's full scale sensitivities may be adjusted under these conditions.

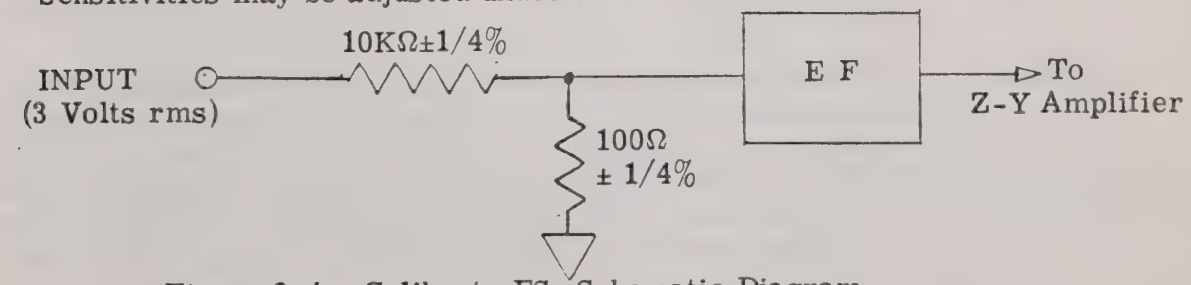


Figure 3-4. Calibrate FS, Schematic Diagram

3-7 Impedance Measurement

In the Z position of the MODE switch, one of 12 precision constant current resistors R_Z is placed in series with the unknown, each constant current resistor being 100 times the full scale value of unknown impedance (except for 10K, 25K and 50K ohm positions where the resistor is maintained at 500K ohms). Thus, the output is proportional to the amplitude of unknown impedance, having a phase equal to the phase angle of the impedance. A schematic diagram of the circuit when the Range switch in positions from 10 ohms to 5K ohms is shown in figure 3-5.

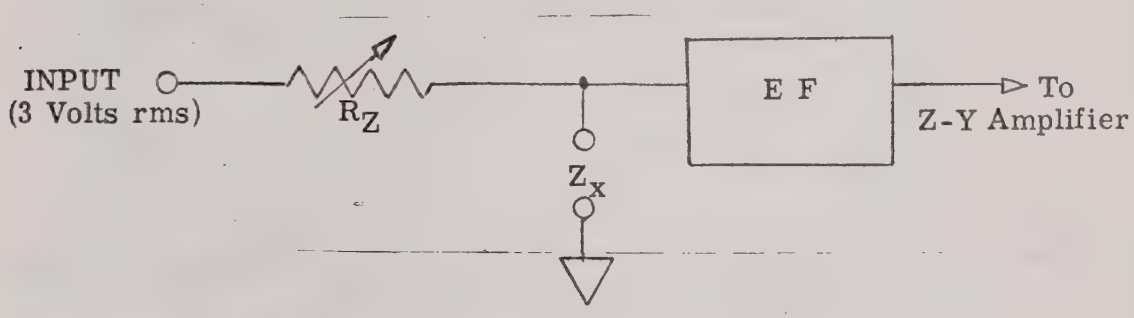


Figure 3-5. Impedance Measurement for Ranges of 10 Ohms Through 5K Ohms, Schematic Diagram

To minimize the effects of shunt capacitance across the constant current resistor at high frequencies, the largest constant current resistor used is 500K ohms. This fixed value is used for RANGE switch positions: 5K ohms, 10K ohms, 25K ohms and 50K ohms. In order to maintain this resistance constant for different impedance ranges, it is necessary to reduce the input voltage for the higher impedances. This is shown in the schematic diagram, figure 3-6.

In the arrangement of figure 3-6, the operator should note that at the higher impedance ranges the current through the unknown can no longer be considered entirely constant, since the unknown impedance may be an appreciable value compared to R_Z. It is recommended that for the accurate measurement of high impedances with the standard plug-in (Model 100-PA-1001), the operator should check by use of the admittance mode.

If high impedance measurements are required at lower frequencies, the compromise of figure 3-6 is not necessary, and a special plug-in can be provided to maintain the constant current resistor at least 100 times the unknown for all ranges.

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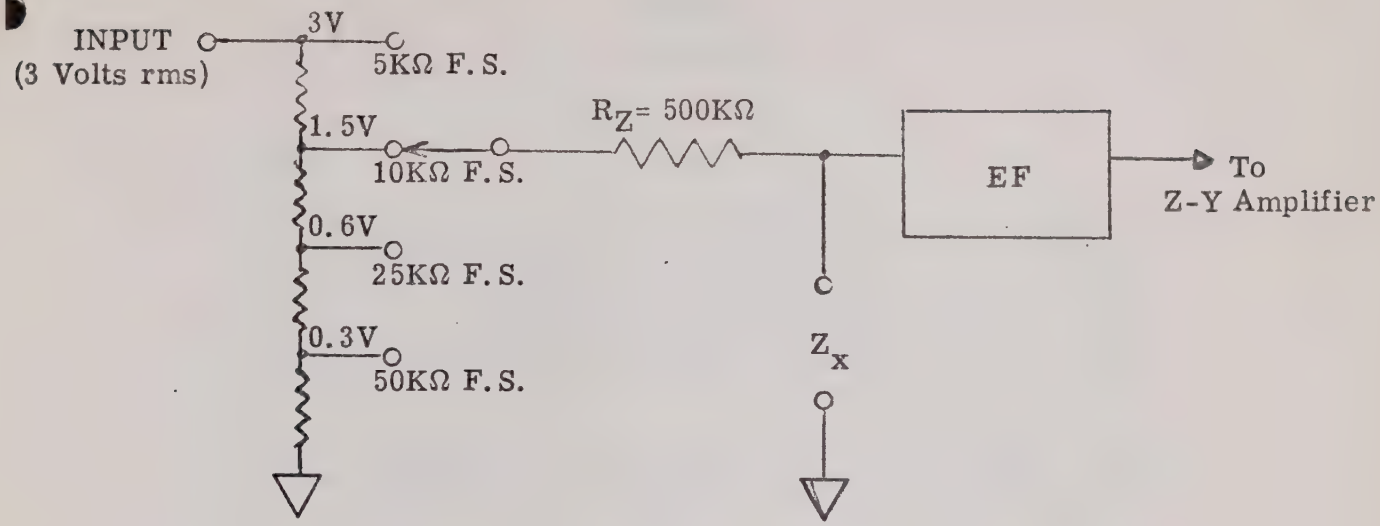


Figure 3-6. Impedance Measurement for Full Scale Ranges of 5KΩ, 10KΩ, 25KΩ and 50KΩ, Schematic Diagram

3-8 Admittance Measurement (See figure 3-7.)

In this measurement, the resistor in series with the unknown is grounded and is much smaller than the value of the unknown impedance. Hence, the entire 3-volt signal is impressed across the unknown, and the voltage developed across R_Y, proportional to and in phase with the current, is proportional to the amplitude of unknown admittance with a phase angle equal to that of the unknown admittance. The admittance circuit arrangement of this plug-in, because it utilizes the output of a grounded emitter follower as a signal source, requires that the unknown admittance be maintained off ground. Provision is made for testing grounded admittances if other plug-in modules are used.

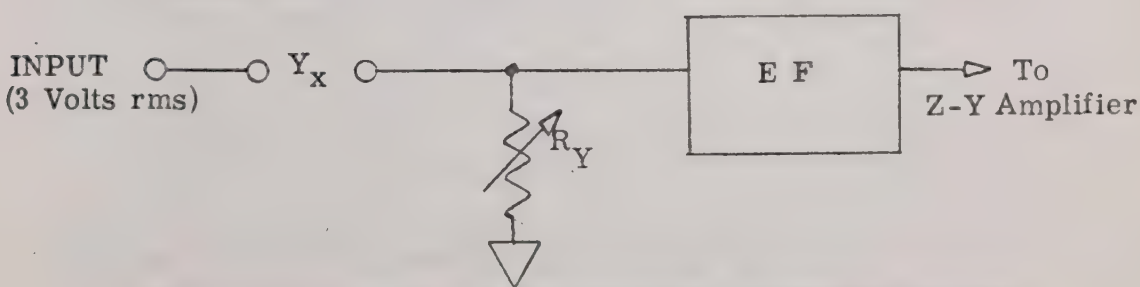


Figure 3-7. Admittance Measurement, Schematic Diagram

SECTION IV

MAINTENANCE

4-1 GENERAL

4-2 This section contains the information necessary for troubleshooting the Complex Impedance-Admittance Meter. The troubleshooting procedures for this equipment are designed to isolate malfunctions to major circuit subdivisions. These procedures utilize the signal tracing method of trouble analysis. With this method, operating conditions are maintained and indications in the signal path are observed.

4-3 Schematic diagrams of the front panel showing all controls, and of the rear panel showing all plug-in connectors with signal and voltage data are included. (See drawings Nos. 100,042 and 100,043.)

4-4 TROUBLESHOOTING PROCEDURE

4-5 The Complex Impedance-Admittance Meter utilizes plug-in circuits throughout for ease of maintenance. A test adapter, mounted on the rear of the main chassis inside the carrying case, is provided to simplify troubleshooting. The test adapter can be inserted between internal plug-in modules and the main chassis for exposing the plug-in terminal connections. All troubles are isolated with conventional test equipment.

4-6 Table 4-1 is a trouble analysis chart that describes the troubleshooting procedures that can be performed to locate defective plug-in modules (figure 4-1). The equipment should be set up for normal operation observing all precautions noted in the operating procedure, Section II.

4-7 The Complex Impedance-Admittance Meter includes the following plug-in modules:

Main Assembly
- D-C Regulator
- 90° Phase Shift Network
- Power Emitter Follower
- Squaring Amplifier
- Z-Y Amplifier and Limit Relay
- Quadrature Resolver
- In-Phase Resolver

Impedometer-Admittometer Plug-in

Whenever maintenance of a plug-in module is required, it should be returned to Dranetz Engineering Laboratories, Inc.

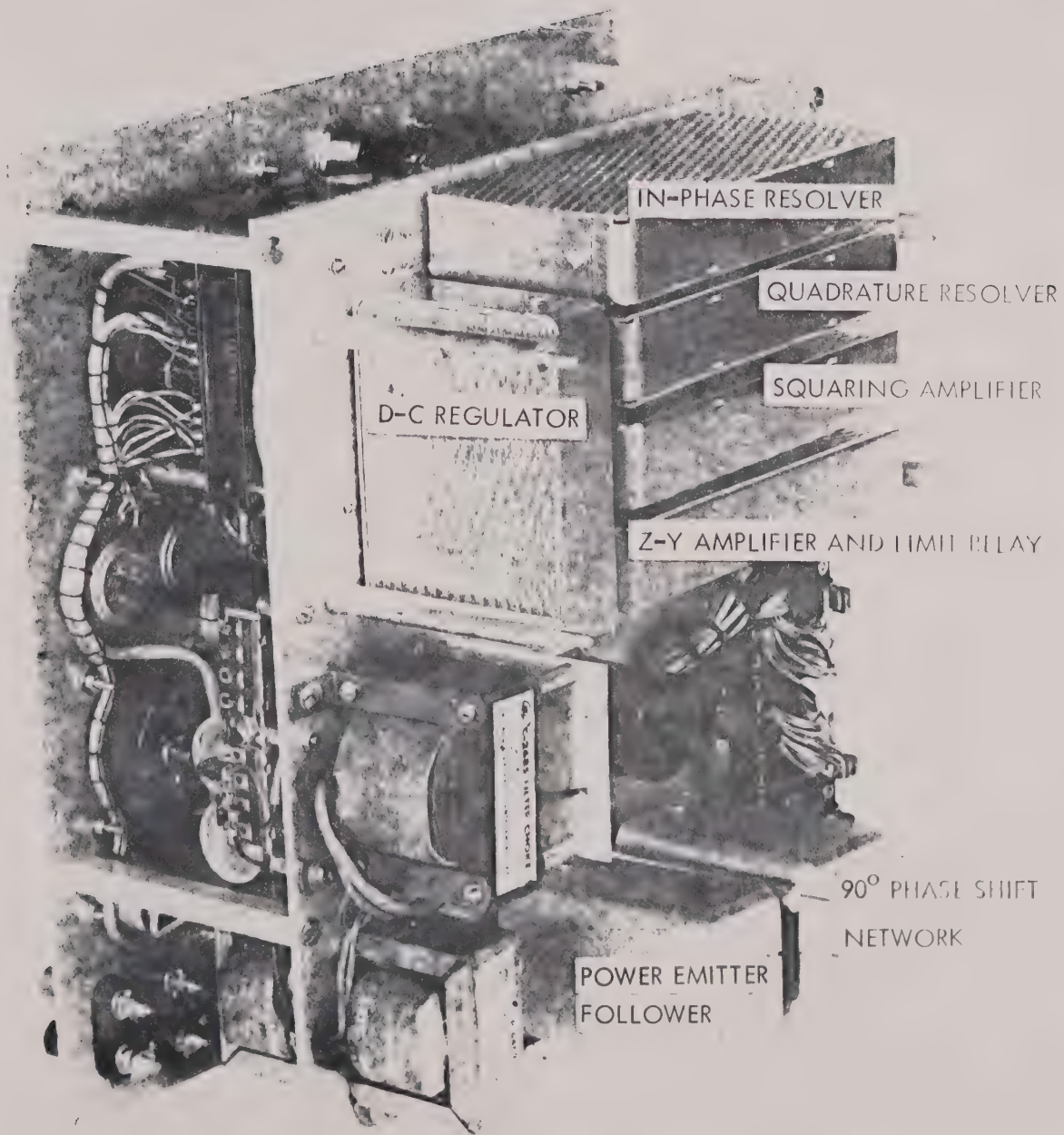

IN-PHASE RESOLVER
QUADRATURE RESOLVER
SQUARING AMPLIFIER
D-C REGULATOR
Z-Y AMPLIFIER AND LIMIT RELAY
90° PHASE SHIFT
NETWORK
POWER EMITTER
FOLLOWER

Table 4-1 Complex Impedance-Admittance Meter, Trouble Analysis Chart

STEP	INSTRUCTIONS	NORMAL INDICATION	PROBABLE CAUSE OF ABNORMAL INDICATION
	NOTE All of the following checks are performed with the equipment set up for normal operation. (See paragraphs 2-2 through 2-5, Section II.) The following checks require an external amplifier with a maximum of 4 ohms source impedance and capable of delivering a 3-volt rms undistorted signal at 2 watts power. Operate equipment at 1 Kc with the OUTPUT FILTER switch in NORM position		
1	Connect test adapter between connector J6 and D-C Regulator and measure voltages at terminals. NOTE All voltage measurements are made using a VTVM. Connect ground terminal of VTVM to GROUND terminal on front panel of Impedometer-Admittometer plug-in.	Pin — Volts DC 1 — +22.5 7 — - 6.2 9 — - 2.0 16 — -17.0 18 — +27.0	Defective D-C Regulator, or if voltages are incorrect, proceed with steps 2 and 3.
2	Remove Impedometer-Admittometer plug-in. (This removes load.) Connect a simulates load of approximately 60 ohms 20 watts across pins 1 and 5 of J6. Measure voltages between J6 terminals and the respective ground for each voltage source: a. between pins 1 and 5 b. between pins 7 and 5 c. between pins 9 and 5 d. between pins 16 and 11 e. between pins 18 and 12	Pin — Volts DC 1 — +22.5 7 — - 6.5 9 — - 2.4 16 — -20.0 18 — +27.0	If all voltages are present, remove one plug-in module at a time to isolate shorted module. If -20 vdc and/or +27 vdc are not present, defective Rectifier Filter. If individual outputs are incorrect, defective D-C Regulator. If all outputs are incorrect, proceed with step 3.

Table 4-1 Complex Impedance-Admittance Meter, Trouble Analysis Chart (cont)

STEP	INSTRUCTIONS	NORMAL INDICATION	PROBABLE CAUSE OF ABNORMAL INDICATION
3	Measure a-c input at pins 1 and 13 of connector J7.	115 VAC	Defective connections or "on-of" switch.
4	Connect unit for normal operation with Impedometer-Admittometer plugged in. Set INPUT SELECT switch to OSC position and observe A-C voltmeter.	3 VAC	If unit functions incorrectly in EXT. OSC. position but correctly in EXT. AMP. position, defective Power Emitter Follower.
	Connect external oscillator and external amplifier to EXT. AMP. terminals. Adjust output of power amplifier as specified in paragraph 2-3. Observe A-C voltmeter.	3 VAC	
5	Connect test adapter between connector J2 and Z-Y Amplifier and Limit Relay. Connect an oscilloscope and an HP400H VTVM or equivalent between pin 7 of J2 and ground. Set MODE switch to calibrate 0 position and observe indicators.	Less than 1 mv random noise pattern.	If output is excessive, defective Impedometer-Admittometer plug-in or Power Emitter Follower.
	Set MODE switch to calibrate FS and record A-C output.	30 Mv.	Defective Impedometer-Admittometer plug-in.
6	Connect a decade box across UNKNOWN terminals to supply a range of resistances of at least 1% accuracy: 10, 25, 50, 100, 250, 500, 1K, 2.5K, 5K, 10K, 25K and 50K. NOTE Unknown resistance should be equal to setting of controls on front panel. Set MODE switch to Z and measure A-C output for each resistance.	30 mv rms undistorted sine wave.	Defective Impedometer-Admittometer plug-in.

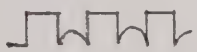
Table 4-1 Complex Impedance-Admittance Meter, Trouble Analysis Chart (cont)

STEP	INSTRUCTIONS	NORMAL INDICATION	PROBABLE CAUSE OF ABNORMAL INDICATION
7	Set MODE switch to Y and measure A-C output for each of the following resistances. Set RANGE control setting to correspond to the following resistance values: NOTE Decade box must be ungrounded for the admittance checks. RANGE control setting / Resistance on UNKNOWN terminal 10 — 100K 25 — 40K 50 — 20K 100 — 10K 250 — 4K 500 — 2K 1K — 1K 2.5K — 400 5K — 200 10K* — 100* 25K* — 40* 50K* — 20* * Connect external amplifier for these checks.	30mv rms undistorted sine wave.	Defective Impedometer-Admittometer plug-in.
8	Connect test adapter between connector J3 and Squaring Amplifier. Connect VTVM to measure output at pin 7 of J3. Place a 100-ohm resitor across UNKNOWN terminals. Set MODE switch at Z and RANGE switch at 100 ohms. Measure A-C voltage at pin 7 of J3 for the following conditions: (a) With FREQ RANGE switch at 0.1 - 2KC, measure output at 100-cps and 2-kc inputs.	45 mv ± 10 mv	Defective 90° Phase Shift Network.
	(b) With FREQ RANGE switch at 1 - 20 KC, measure output at 1-kc and 20-kc inputs.	45 mv ± 10 mv	
	(c) With FREQ RANGE switch at 10 - 200 KC, measure output at 10-kc and 200-kc inputs.	45 mv ± 10 mv	

Table 4-1 Complex Impedance-Admittance Meter, Trouble Analysis Chart (cont)

STEP	INSTRUCTIONS	NORMAL INDICATION	PROBABLE CAUSE OF ABNORMAL INDICATION
9	Connect test adapter between connector J2 and Z-Y Amplifier and Limit Relay. Set MODE switch to calibrate FS and measure A-C voltage with VTVM at pin 7 and pin 11 of J2.	Imput of 30 mv at pin 7. Output of 0.75 volts at pin 11.	See Step 5
10	Connect a 500-ohm variable resistor across UNKNOWN terminals, set MODE switch to Z and RANGE control setting to 100 ohms. Vary resistor and observe A-C voltage at pin 11 of J2.	Limit Relay should operate at 1.8 volts (limit indicator lights) and should reset at approximately 1.3 volts (limit indicator goes off).	Defective Z-Y Amplifier and Limit Relay.
11	Connect test adapter between connector J3 and Squaring Amplifier. Set FREQ RANGE switch to 0.1 - 2KC position. Set external oscillator to 1 KC, and check a-c input voltage at pin 7 of J3.	Approximately 40 mv input.	See Step 8
	Using Tektronix 535 oscilloscope or equivalent, observe waveforms at pins 13 and 17 of J3.	A Symmetrical square wave 1 volt peak-to-peak should be observed at both pins 13 and 17.	Defective Squaring Amplifier
12	Connect test adapter between connector J5 and In-Phase Resolver. Set MODE switch to calibrate 0. Observe waveform at pin 13 of J5 and measure d-c voltage with VTVM at pin 18 of J5.	0 volts at pin 18 with zero set pot. adjusted. Unmodulated square wave 3 volts peak-to-peak: 	Defective In-Phase Resolver.

Table 4-1 Complex Impedance-Admittance Meter, Trouble Analysis Chart (cont)

STEP	INSTRUCTIONS	NORMAL INDICATION	PROBABLE CAUSE OF ABNORMAL INDICATION
13	Set MODE switch to calibrate FS and observe waveform and measure d-c voltage as in step 12.	+1 volt D-C Modulated square wave, approximately 4 volts peak-to-peak: 	Defective In-Phase Resolver.
14	Connect test adapter between connector J4 and Quadrature Resolver. Set MODE switch to calibrate 0. Observe waveform at pin 13 of J4 and measure d-c voltage with VTVM at pin 18 of J4.	0 volts at pin 18 Unmodulated square wave approximately 3 volts peak-to-peak: 	Defective Quadrature Resolver.
15	Set MODE switch to calibrate FS and observe waveform and measure d-c voltage as in step 14.	-1 volt D-C Modulated square wave, approximately 3 volts peak-to-peak: 	

AMENDMENT TO INSTRUCTION BOOK

CIAM MODEL 100B

A. SECTION 1-15

Delete and substitute the following

1-15 INSTALLATION

a. Non-rack installation
The instrument is shipped ready for operation. Special instructions are given below.

(1) Connect instrument 115 volt 60 cps power.

(2) Grounding
The instrument must be grounded at the ground terminal (located on the front of the Impedometer-Admittometer plug-in) or through the power cable, but not at both places.

Note 1: Main frame units having serial numbers through 21 have a fuze (F2) in the power line ground circuit. Higher serial numbered units do not.

Note 2: Impedometer-Admittometer plug-ins (Model 100-PA-1001) having serial numbers up to #21 have chassis and circuit grounds permanently connected. Starting with serial #22, power line ground, circuit ground, and chassis ground appear on three separate screw terminals (see section on 100-PA-1001) inside the plug-in (front panel ground is CIRCUIT ground). Unless the case may be connected to another electrical ground, it is suggested that for non-rack operation the circuit ground and chassis ground terminals be connected.

CAUTION

DO NOT APPLY D-C VOLTAGE
ACROSS ANY EXPOSED TERMINALS
OF THIS INSTRUMENT

b. Rack mounted units

(1) Installation
Mounting to a 19" rack is accomplished by the addition of an auxiliary 1/8" thick plate between the front panel and carrying case of the instrument. This auxiliary plate also has two cut-outs for storing plug-ins.

On orders for rack mounted units, the auxiliary plate is generally shipped unmounted to provide better shipping protection and allow the instrument to be used portably at a later date if so desired. The procedure for installing the plate is as follows.

(a) Place the CIAM-100B on a bench top, with cover facing up and handle facing to the rear.

(b) Remove all 12 binding head screws (#4) located around the edge of the front panel, set the instrument up so that the handle faces up, retract the instrument from its carrying case and set this aside. Turn the empty case back to its original position, handle away.

(c) Remove the bag of four screws attached to the rack mounting plate, and with the side having threaded inserts facing downward, place the plate on the open end of the box, centering the large cut out over the opening, with the covered holes for adapters to your right.

(d) Pick up the CIAM-100B assembly and place it in the cut out of the rack mounting plate, making sure that engraving is readable, that box handle is away, and adapter cut outs are on right.

(e) Attach 100-B assembly to rack mounting plate, using 8 of the 12 original screws (do not install in corners).

(f) Observe whether mechanical interferences occur between rear box and other devices mounted in the rack. If necessary then side clasps, carrying handle and rubber feet can be removed easily be removing screws and nuts fastening these items.

Then using the 4 longer screws supplied with rack mounting, attach the front panel to the rear box through the four corner holes.

Note 1: Do NOT destroy the box cover. This can be used whenever it is desired that the instrument be used portable.

Note 2: The ventillator holes should not be blocked when the unit is rack mounted.

(2) Grounding
To avoid circulating grounds, it is recommended that all three grounds be left disconnected in the front panel plug-in if the rack system is grounded. In this manner the circuit ground can be connected separately to the main ground.

Note: The chassis ground terminal is used internally as a common for all shields (except those which are driven--for example, in the plug-in). Thus if the main rack is NOT ground, this may result in a good deal of pickup.

CAUTION

THE SYSTEM OF GROUNDING MAY BE VERY IMPORTANT, PARTICULARLY IN COMPLEX MEASURING SYSTEMS, SUCH AS INVOLVING ELECTROACOUSTICAL TRANSDUCER MEASUREMENTS. THIS IS PARTICULARLY TRUE WHEN MAKING LOW LEVEL MEASUREMENTS. THE BEST RULE TO FOLLOW IS TO MAINTAIN A SINGLE COMMON RETURN POINT.

B. Functions of controls, indicators and terminals.
In Model 100-B units having serial numbers up to and including #29, the fuze F3 is located on the back of the rear panel. On units having serial #30 and higher, this fuze is located on the front panel of the instrument midway between the EXT..OSC and EXT AMP. binding terminals.

3-4 STANDARD IMPEDOMETER ADMITTOMETER 100-PA-1001 CHANGES
Plug-ins having serial numbers of #21 or less are described in the instruction manual. Units having serial numbers of #22 or higher are changed as follows:

1. Paragraph 3-7 Impedance Measurement
The constant current arrangement shown in Figure 3-5 is used for ALL impedance ranges. With the constant current resistor being 100 times the indicated full scale value of impedance for ALL ranges.

2. On all units, circuit ground, chassis ground and power line ground are brought individually into the Impedometer-Admittometer plug-in for interconnection. In 100-PA-1001 units with serial #21 or lower, these grounds are permanently connected and brought to its GROUND terminal on the front panel. On units of higher serial numbers, the grounds are brought into separate screw type terminals within the housing with the front panel GROUND terminal being circuit ground. The operator has the option of ground interconnection to suit his need best (see earlier section of this amendment).

ADDITIONAL INSTRUCTION SHEET

FOR

PLUG-IN IMPEDOMETER ADMITTOMETER

MODEL 100-PA-100A

All units of this model plug-in incorporates the ground, and constant current source features described for the 100 PA-1001 for serial # 22 and thereafter.

In addition, this plug-in incorporates a switch by which the output phase of the quadrature channel can be reversed. This is particularly useful when plotting the logarithm of a negative reactance, since many logarithmic amplifiers are not capable of handling negative d.c. voltages. It should be noted that the switch reverses the polarity of the quadrature channel both at the output terminals and across the panel meter. Thus with the switch in the reverse position, the meter will read positively when the MODE switch is in the CAL FS position.

AMENDMENT B TO INSTRUCTION MANUAL

CIAM MODEL 100B

Add the following to SECTION II - OPERATION

2-8 Effects of distortion and noise in oscillator signal.

Because of the frequency sensitivity of internal networks and of the unknown under test, it is important that the input signal be a clean sine wave, free of harmonics and out of band noise. Generally maintaining total harmonic distortion below 0.5% will be satisfactory. Below are some problems which have been encountered along with means for their avoidance.

(a) Noise

(1) The problem

The presence of noise (even out of band) in the 3 volt rms input, may cause one of several problems. First, low frequency noise may not be completely filtered out in the resolvers, resulting in a non-periodic change in panel meter readings and d.c. outputs. In addition, low or high frequency noise may upset the operation of the 90° phase shift network and result in erroneous readings, particularly in the quadrature channel. In particular, the quadrature channel may read properly in the CAL FS position, but have a considerable error when a reactive unknown is connected.

(2) Sources of noise

(a) Certain resistively tuned oscillators generate noise when the tuning potentiometer is moved.
(b) Any oscillator in poor condition.
(c) Beat frequency oscillators may have the high frequency fixed frequency signal riding on the output. This can be checked by an oscilloscope when the problem arises. For this reason, capacitively tuned Wien bridge oscillators are preferred.
(d) Frequency counters are capable of generating sharp pulses into the circuits being measured.

(b) Waveform distortion

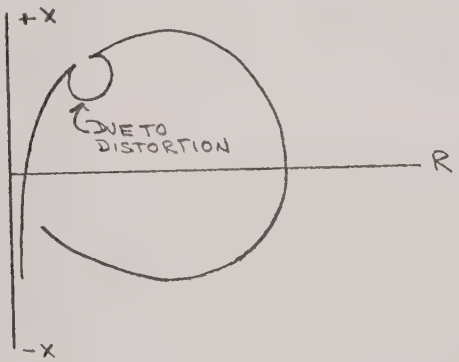
(1) The problem

The synchronous detectors used in this instrument are sensitive to odd harmonics (but not even harmonics) of the reference signal, producing a d.c. output proportional to the following:

Frequency		D.C. Output
Fundamental	V_1	KV_1
3rd harmonic	V_3	$K\frac{V_3}{3}$
5th harmonic	V_5	$K\frac{V_5}{5}$
7th harmonic	V_7	$K\frac{V_7}{7}$

(2) Sources of distortion

(a) The signal source may have distortion either directly, or when certain frequency counters or vacuum voltmeters are connected. Even a small percent of harmonic distortion in the 3 volt signal may be amplified when the unknown has a substantial Q and is resonant at a frequency corresponding to the harmonic components. An impedance plot which has been observed on a parallel tuned circuit under such conditions is given below.



(b) The presence of ripple on a transducer due to d.c. bias may also cause an artifact resonant loop when the test frequency is approximately equal to the ripple frequency or harmonic of the ripple frequency.

Add the following to SECTION IV - MAINTENANCE

4-8 IMPROPER RELAY CLOSURE

Proper closure of the contacts of the LIMIT INDICATOR relay (RL#1) may be impaired by dirt collecting between contacts.

a. Symptoms.

Condition #1 - Inability to make output meters move off zero during operation or when MODE switch is in CAL FS position. Likewise, no d.c. output is attainable. This may take place even though the LIMIT INDICATOR does not light.

Condition #2 - In OPERATION (during overload) meters and outputs indicate zero, but overload lamp does not light. In CAL FS, meters and output read properly.

Condition #3 - During OPERATION, overload, indicator lights, but meters and outputs do not read zero.

b. Correction.

(1) Remove the instrument from its carrying case by removing the 12 screws around the edge of the front panel.

(2) Slip a dry file card or piece of paper between each of the sets of contacts, work back and forth lightly to push out dirt.

APPENDIX C

OPERATING INSTRUCTIONS FOR

IMPEDOMETER-ADMITTOMETER PLUG-IN

Model 100-PA-1001A

The Impedometer-Admittometer Plug-in Model 100-PA-1001A is an updated version of the Model 100-PA-1001. The functions of the units are similar except that the Model 100-PA-1001A has additional and improved features such as:

(1) Normal - Quad. Rev. Switch
(2) Sig. Mon. Test Points
(3) Separate unknown Z or Y terminals. The following Table describes the function of controls for the 100-PA-1001A Plug-in. The location of these controls are shown in Figure C-1. Drawing No. 100,848 is an internal view showing position of ground terminals and location of switch decks. Drawing No. 100,787 is a schematic diagram of this plug-in unit.

Index No.	Control, Indicator or terminal	Function
1	CAL 4-position switch Z-O-FS-Y	Selects precalibration and operation modes: Y - Admittance. FS and O - Adjustment for calibration of zero and full scale positions only. Precalibration holds for any amplitude range of impedance or admittance. Z - Impedance.
2	Ohm or Micromho 12-position range switch 12 positions: 10 - 25 - 50 - 100 - 250 - 500 - 1K - 2.5K - 5K - 10K - 25K - 50K	Presets full-scale ranges for admittance and impedance. Impedance is indicated in series resistance or reactance. Admittance is indicated in parallel conductance and susceptance.
3	Unknown Z terminals Red - High side Black - GRD. side	Five way terminals for measuring impedance.
4	Unknown Y terminals Red - HIGH Black - LOW	Five way terminals for measuring admittance. Note that for admittance measurement, both terminals are ungrounded.

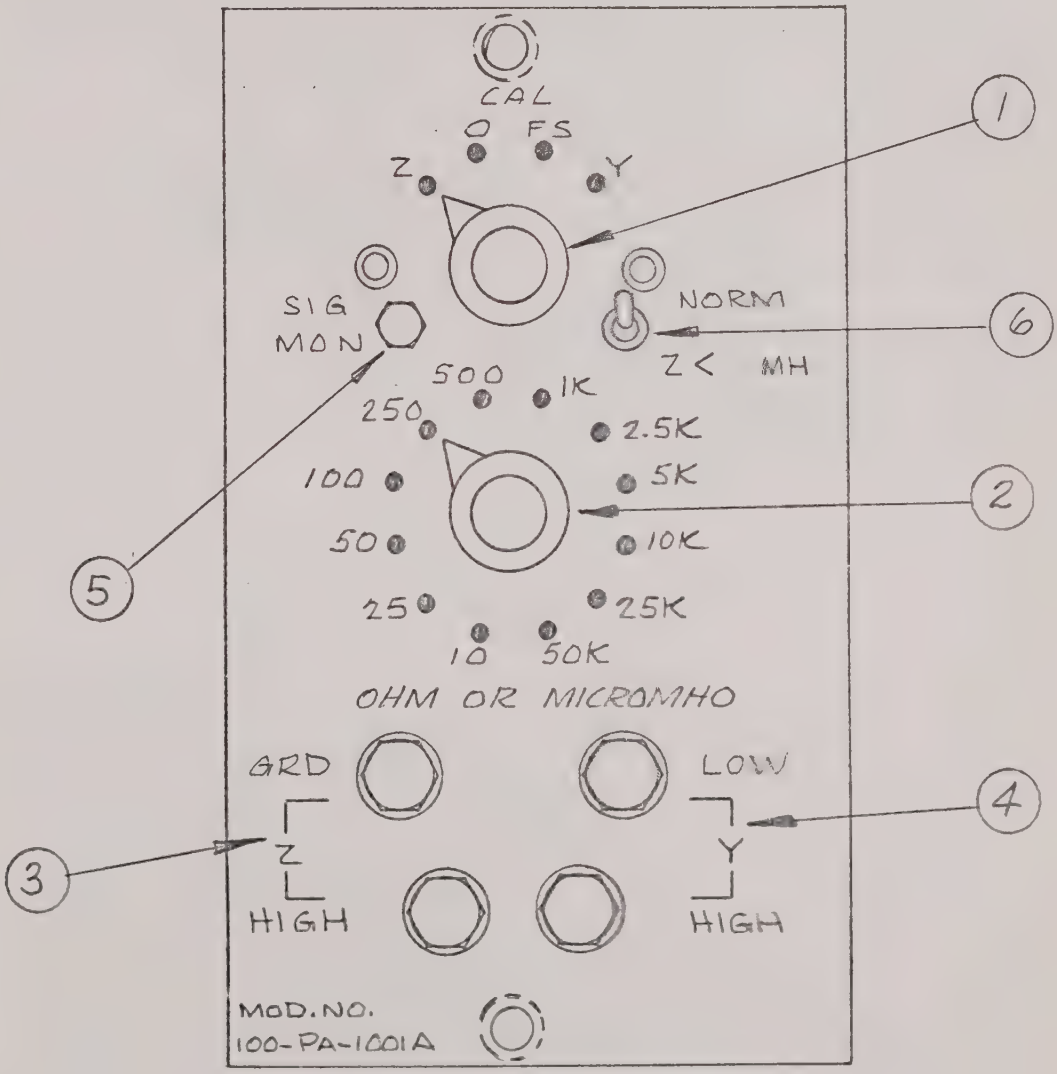


Figure C-1

Impedometer-Admittometer Plug-In
Model 100-PA-1001A Controls

Index No.	Control, Indicator or Terminal	Function
5	SIG. MON. Test Point	Provides a monitor output signal of 30 millivolts for trouble shooting, observing the waveform of voltage across the unknown when measuring Z, and observing the voltage (representing current through the unknown) for measuring Y. The SIG. MON. test point can be used as a guard when required in the same manner described in the basic handbook.
6	NORMAL-QUAD. REV. Toggleswitch	In normal position, the d-c output and meter reading will provide a direct reading of the parameter being measured. In QUAD. REV. position, all direct readings are phase inverted by 180° and is only necessary when the recording instrument requires positive going voltages for all measurements.

ISSUE	REV.
A	CHANGED T1 TO J1-31 - SW2-1 TO F3-2
B	CHANGES APPLY TO UNITS SER #16 & THROUGH 29 B-1 CHANGED CONNECTION ON T1 & T3 FROM F3-2 (REAR PANEL) TO J1-31 (REAR PANEL) B-2 CHANGED CONNECTION ON SW2-1 FROM J1-10 TO F3-2 (REAR PANEL)
C	CHANGES APPLY TO UNITS SER #30 & FOLLOWING C-1 FUSE F3 WAS LOCATED FROM REAR PALEL (D100,043) TO FRONT PANEL
D	REVISED TO & T2 CONNECTION BY F. DEF AL NO 2/2 5/1/64

CONNECTED TO J7 MOUNTED ON REAR PANEL (REF)

P7 23 22 21 24 2 3 13 14 8 7 6 11 5 12 10 9

TB9-1 TB9-2 TB9-2 S7 INTERLOCK SWITCH R4

SW3 1 (FS) 2 (½FS) 3 (0) R7 R6 R8 R9 R2 M1 R INCREASE J1-28 TB9-1 LO

(R) METER CIRCUIT

SW4 1 (FS) 2 (½FS) 3 (0) R11 R10 R12 R13 10K OHMS R3 M2 X

(X) METER CIRCUIT

M3 AC HI LO

F1 ½A J10 INPUT AC POWER DS1 SW6 DS2 LIMIT IND.

J2-3 J2-7 J3-6 J3-12 J4-5 J4-3 J4-7 J4-9 J5-5 J5-3 J5-7 J5-9 A B C D E F G H I J

J3-3 J3-10

SW5 FILTER SWITCH NORM. POSITION

LO J1-31 OSC EXT HI J1-4 LO AMPL EXT

J9-4 EF. OUTPUT F3 1A J1-10 SW2 AMPL. EXT. SEL.

J8-9 J8-10 J8-11 J8-6 J8-7 J8-8 SW1 FREQ. SELECTOR J1-20 J1-18

THESE LEADS INDICATED IN THIS BOX ARE WIRED DIRECT TO REAR PANEL.

ALL SHIELD CONNECTIONS TB9 P7-6 CASE GRD

NOTE:
FOR REAR PANEL WIRING DIAGRAM
SEE DWG D100,043

△ INDICATES CHANGES REVISIONS SEE BOX FOR REV INFORMATION

LEGEND
INDICATES 4 TWISTED WIRES

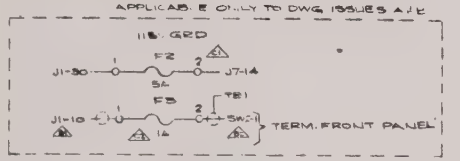
DRANETZ ENGINEERING LABS INC.
11 WASHINGTON AVENUE, PLAINFIELD N.J.

SCHEMATIC WIRING DIAGRAM
FRONT PANEL MODICUB

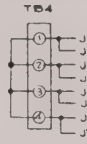
DWG. BY: JB	CKD BY: JR	C	100,042	D
APP BY: JB	DATE 7-2-63	SIZE		REV

REV.	REVISIONS
B	ELIMINATED APPL. TO SER # 429 A CHANGED CONNECTION ON TB-1 TO -10. B1, CHANGED CONNECTION ON TB-2 FROM T1 & T3 (FRONT PANEL) TO SW2-1 (FRONT PANEL) B3, CHANGED CONNECTION ON J1-10 FROM SW2-1 (FRONT PANEL) TO F3-1 (FRONT PANEL) B4, CHANGED CONNECTION ON J1-3 FROM F3-1 TO T1 & T3 (FRONT PANEL)
C	CHANGES APPLY TO UNITS SERIAL # 304 FOLLOWING C1, ELIMINATE FUSE F2 - TERMINAL J7-14 WIRED DIRECTLY TO J1-30 C2 FUSE F3 REMOVED FROM REAR PANEL AND RELOCATED TO FRONT PANEL (C100,042)
D	CHANGE CAP. C-1 FROM 64uF TO 200uF START SER 28
E	CHANGE W2 WIRE NO. TO CASE GRD TERMINAL 2 ON ALL CONNECTOR CASE GRD CONNECTION RUNS DIRECTLY TO CHASSIS SWITCHED GRD. DO NOT USE FROM CASE GND PA 7/1/66
F	J1-28, ADDED LEAD TO T6 & T8 APPLIES TO SER # 43 DA 7/1/66
G	J1-16, ADDED LEAD TO J3-16 J3-16 WAS CASE GRD J3-18 CASE GRD ADDED APPLIES TO SER # 57 DA 7/1/66

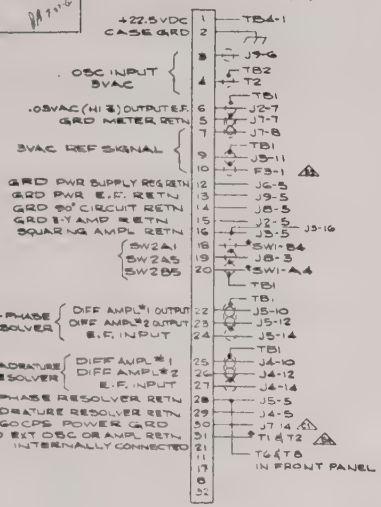
APPLICABLE ONLY TO DWG. ISSUES A & B

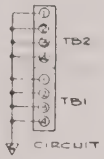


B+ DISTRIBUTION +22.5 V



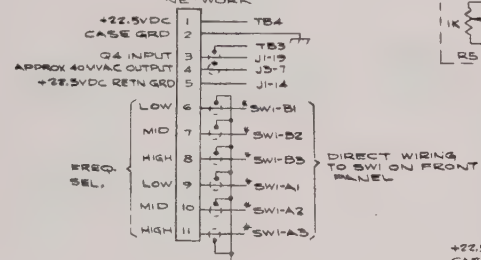
J1 IMPEDOMETER ADMITTOMETER PLUG-IN

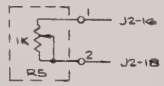




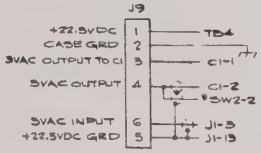
NOTES:
1. FOR FRONT PANEL SEE DWG C100,042.
2. INDICATES DIRECT WIRING TO FRONT PANEL.

J8 90° PHASE SHIFT NETWORK

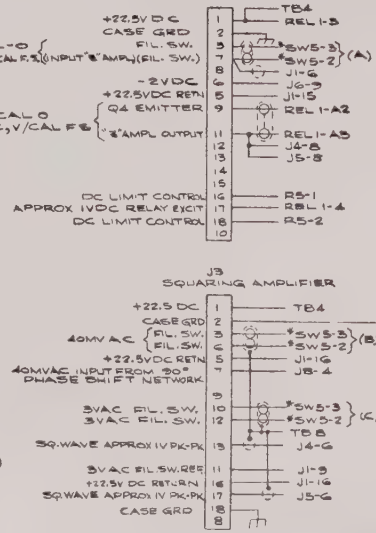




J9

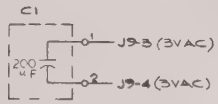


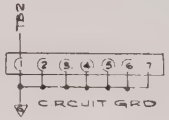
J2 Z - Y AMPLIFIER & LIMIT RELAY



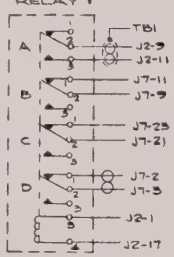
J3 SQUARING AMPLIFIER

C1

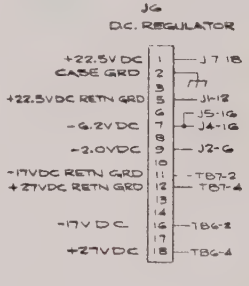


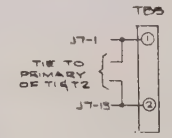


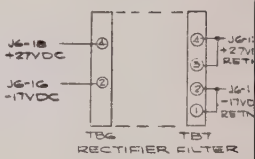
RELAY #1



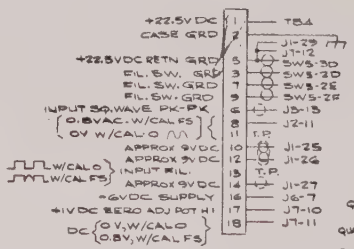
J6 D.C. REGULATOR



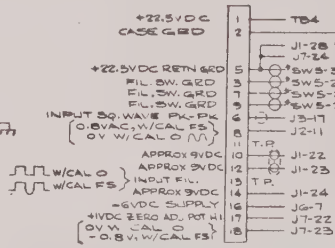




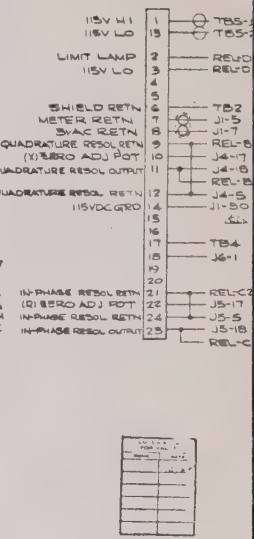
J4 QUADRATURE RESOLVER



J5 IN-PHASE RESOLVER



J7 FRONT PANEL INTERFACE CONNECTOR

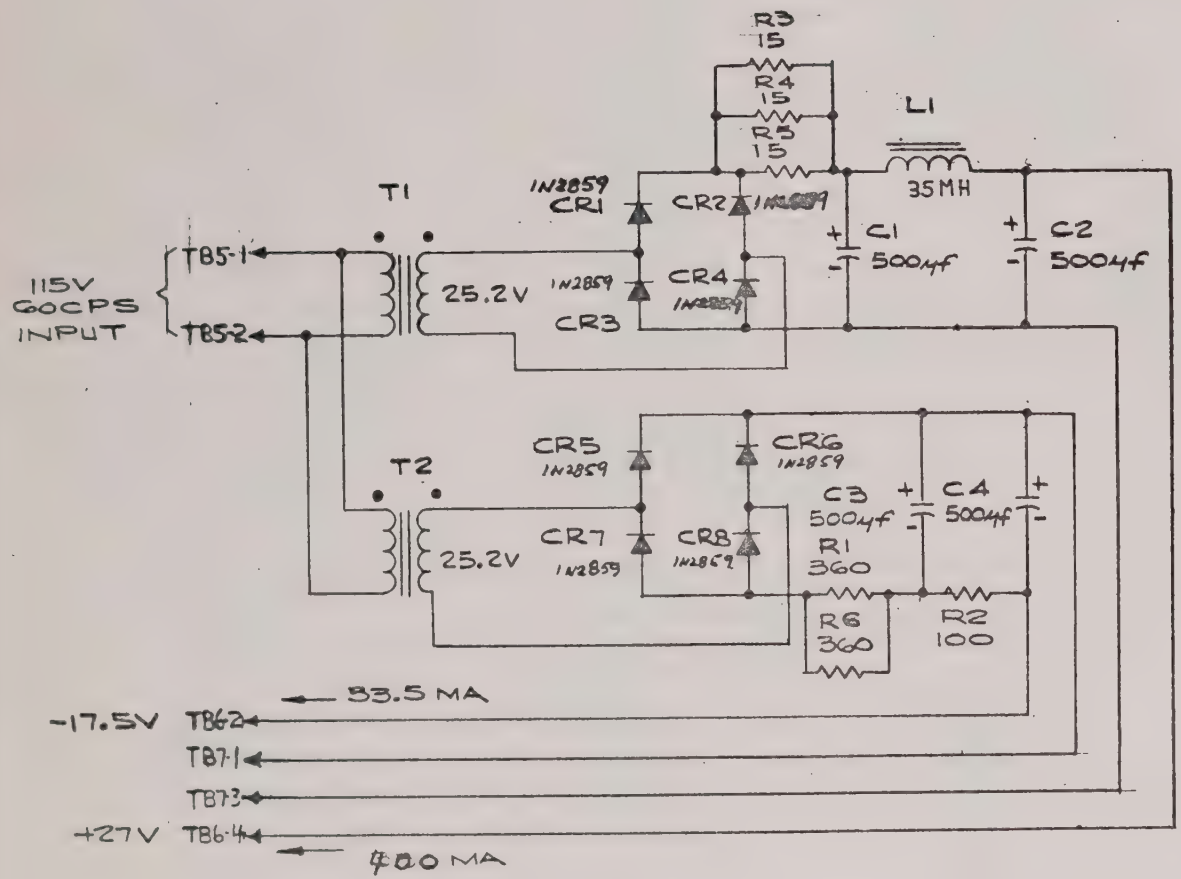


DRANETZ ENGINEERING LABS INC.
11 WASHINGTON AVENUE, PLAINFIELD N.J.

TITLE: SCHEMATIC WIRING DIAGRAM REAR PANEL MOD. 1008

DWG BY:	CHK'D BY:	SIZE	DWG. NO.	REV.
APP BY:	DATE 7/11/67	D	100,043	G

REV	DESCRIPTION



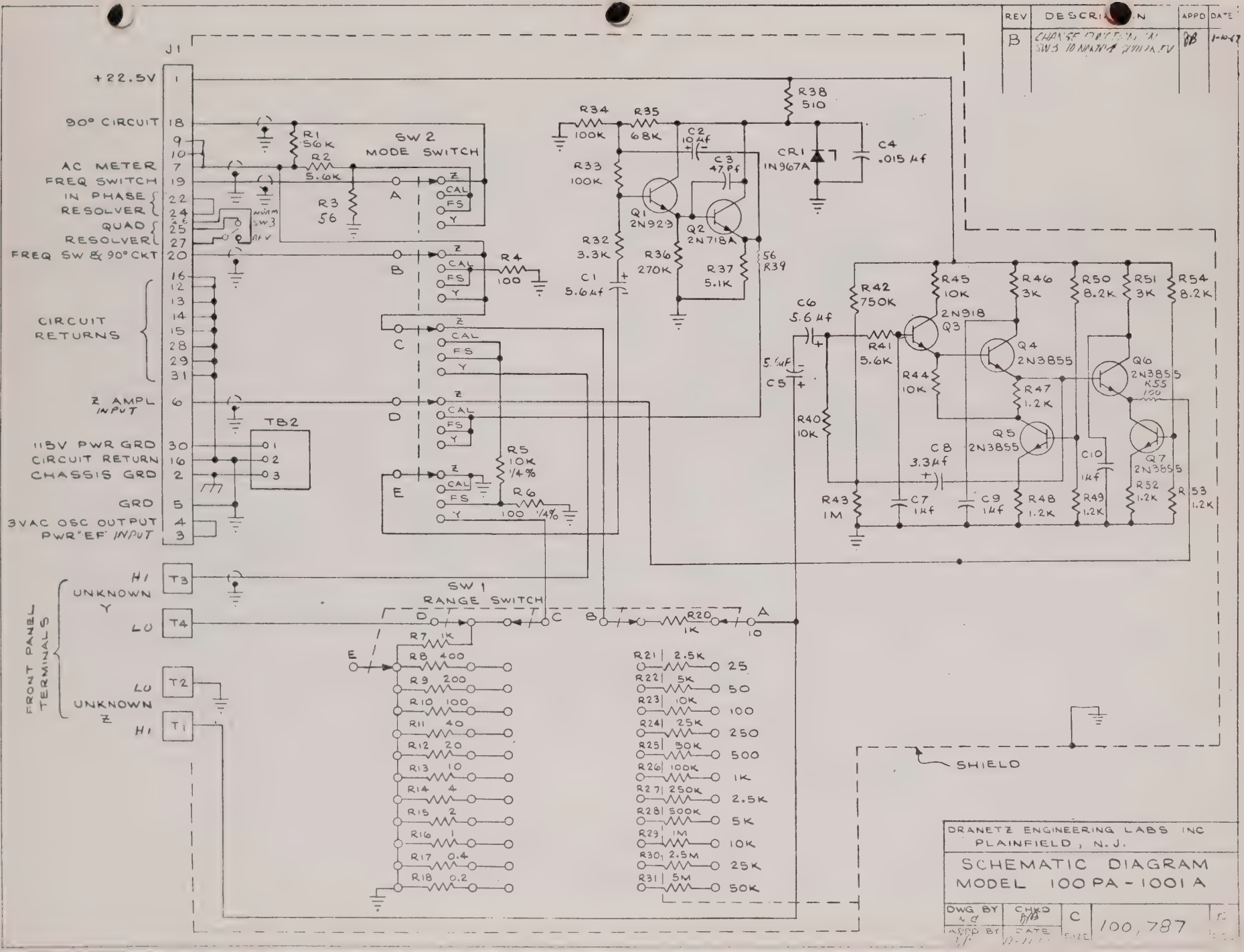
NOTES
1. ALL RESISTORS ARE 5% 1/2 WATT
2. FOR ASSEMBLY DWG SEE D100035

DUPLICATED FOR VAULT	
ISSUE	DATE
A	1-6-64

DRANETZ ENGINEERING LABS, INC.
PLAINFIELD N.J

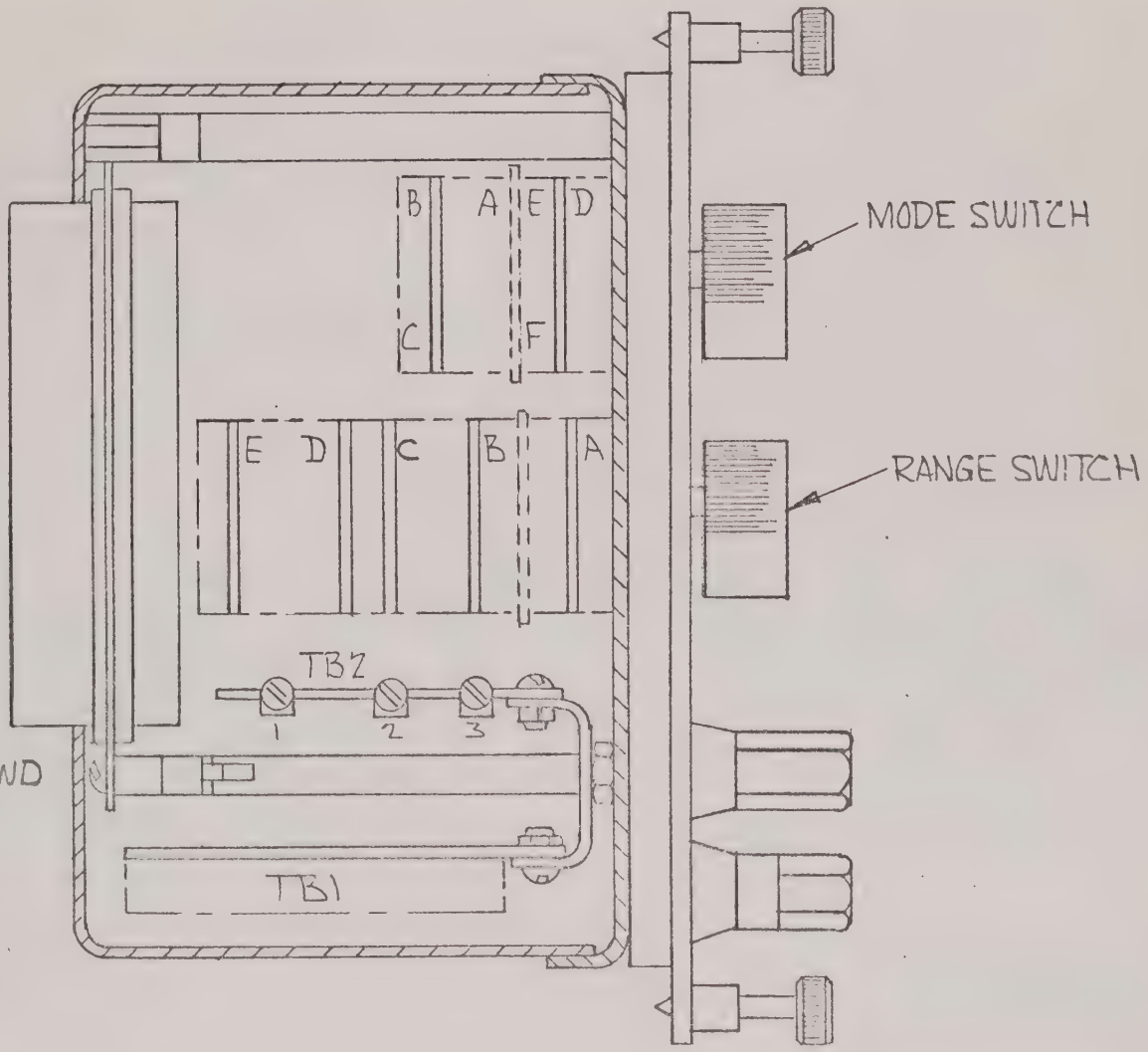
SCHEMATIC DIAGRAM FOR POWER SUPPLY RECTIFIER FILTER

DWG BY	CK'D BY			
APP'D BY	DATE 9/19/63	B SIZE	100,047	A ISSUE


REV
DESCRIPTION
APPD
DATE
B
CHANGE FUNCTION OF SW3 TO NORMAL SYNCH. EV
BB
1-10-67
J1
+22.5V
90° CIRCUIT
AC METER
FREQ SWITCH
IN PHASE RESOLVER
QUAD RESOLVER
FREQ SW & 90° CKT
CIRCUIT RETURNS
Z AMPL INPUT
115V PWR GRD
CIRCUIT RETURN
CHASSIS GRD
GRD
3VAC OSC OUTPUT
PWR REF INPUT
SW 2
MODE SWITCH
NORM
ALT
SW3
R1 56K
R2 5.6K
R3 56
R4 100
R5 10K 1/4%
R6 100 1/4%
TB2
R34 100K
R35 68K
R38 510
C2 10 µf
C3 47 Pf
CR1 IN967A
C4 .015 µf
R33 100K
Q1 2N929
Q2 2N718A
R32 3.3K
R36 270K
R37 5.1K
R39 56
C1 5.6 µf
C6 5.6 µf
C5 5 µf
R42 750K
R45 10K
R46 3K
R50 8.2K
R51 3K
R54 8.2K
Q3 2N918
Q4 2N3855
Q6 2N3855 K55 120
R41 5.6K
R44 10K
R47 1.2K
R40 10K
Q5 2N3855
Q7 2N3855
C8 3.3µf
C10 1µf
R43 1M
C7 1µf
C9 1µf
R48 1.2K
R49 1.2K
R52 1.2K
R53 1.2K
SHIELD
FRONT PANEL TERMINALS
HI UNKNOWN Y
LO
LO UNKNOWN Z
HI
T3
T4
T2
T1
SW 1
RANGE SWITCH
R20 1K
R7 1K
R8 400
R9 200
R10 100
R11 40
R12 20
R13 10
R14 4
R15 2
R16 1
R17 0.4
R18 0.2
R21 2.5K 25
R22 5K 50
R23 10K 100
R24 25K 250
R25 50K 500
R26 100K 1K
R27 250K 2.5K
R28 500K 5K
R29 1M 10K
R30 2.5M 25K
R31 5M 50K
DRANETZ ENGINEERING LABS INC
PLAINFIELD, N.J.
SCHEMATIC DIAGRAM
MODEL 100PA-1001A
DWG BY
CHKD
APPD BY
DATE
SIZE
C
100,787

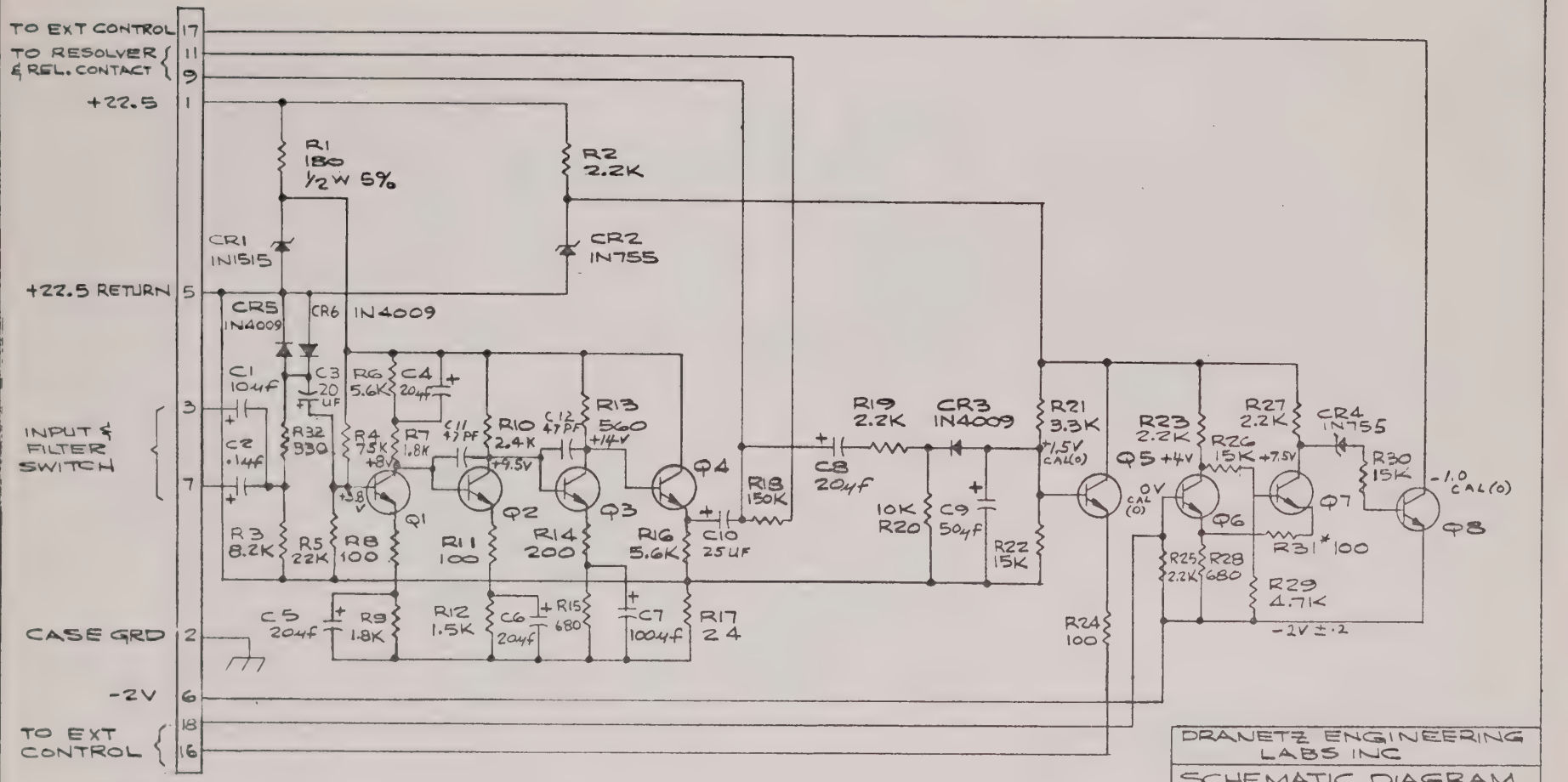
GROUND LINKS

1. POWER LINE GROUND
2. CIRCUIT GROUND MODEL 100 B
3. CASE AND SHIELD GROUND MODEL 100B



INTERNAL VIEW OF
MODEL 100-PA-100A

DWG#A 100 898



NOTE:
1. FOR ASSEMBLY SEE B100,040
2. ALL RESISTOR 1/4 WATT 5% UNLESS OTHERWISE INDICATED
3. ALL TRANSISTORS ARE 2N2221.

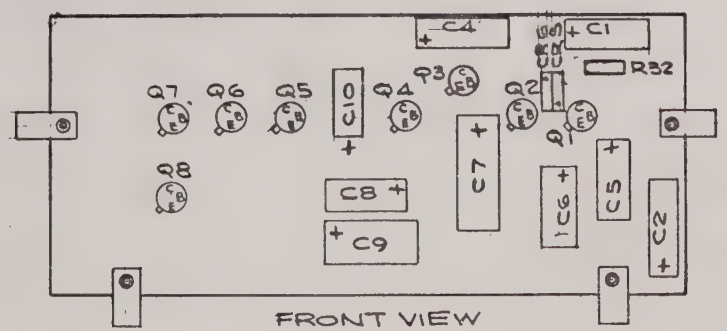
REV	DESCRIPTION

DRANETZ ENGINEERING LABS INC

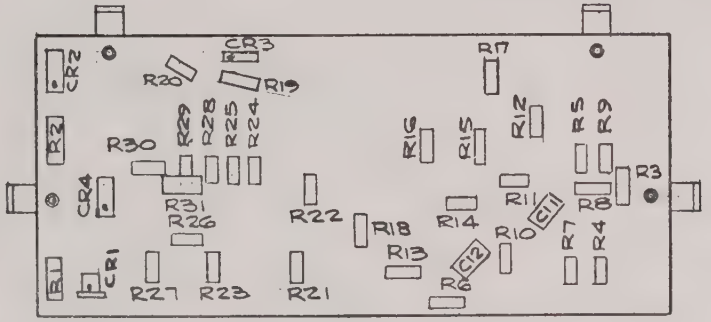
SCHEMATIC DIAGRAM Z-AMP & LIMIT RELAY

DWN BY:	CKD BY:			
APPD BY:	DATE 9/19/83	B SIZE	100,071	A REV

REV	DESCRIPTION



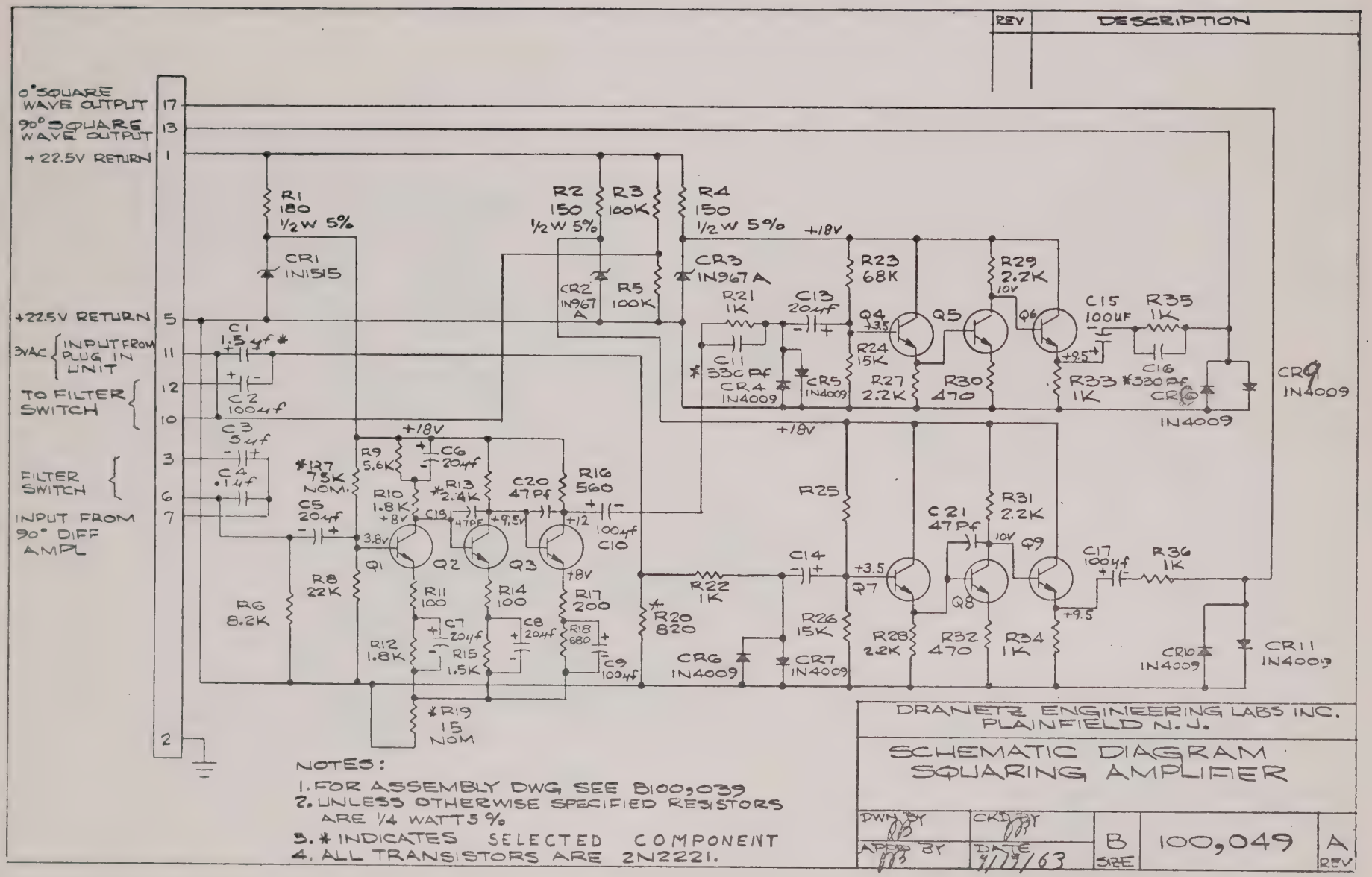
FRONT VIEW



REAR VIEW

NOTE:
SCHEMATIC : B100,071

DRANETZ ENGINEERING LABS INC.				
LAYOUT Z-Y AMPLIFIER				
DWN BY:	CKD BY:	B	100,133	A
APPD. BY:	DATE	SIZE		REV



NOTES:

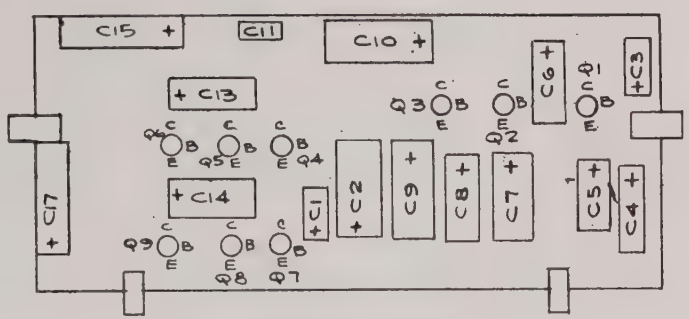
1. FOR ASSEMBLY DWG SEE B100,039
2. UNLESS OTHERWISE SPECIFIED RESISTORS ARE 1/4 WATT 5%
3. * INDICATES SELECTED COMPONENT
4. ALL TRANSISTORS ARE 2N2221.

DRANETZ ENGINEERING LABS INC.
PLAINFIELD N.J.

SCHEMATIC DIAGRAM SQUARING AMPLIFIER

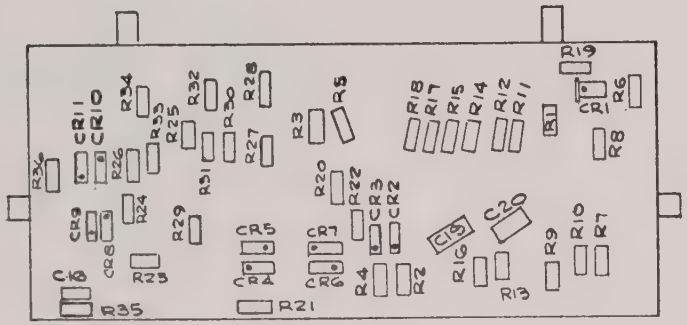
DWN BY	CKD BY			
APVD BY	DATE 4/29/63	B SIZE	100,049	A REV

REV	DESCRIPTION



FRONT VIEW

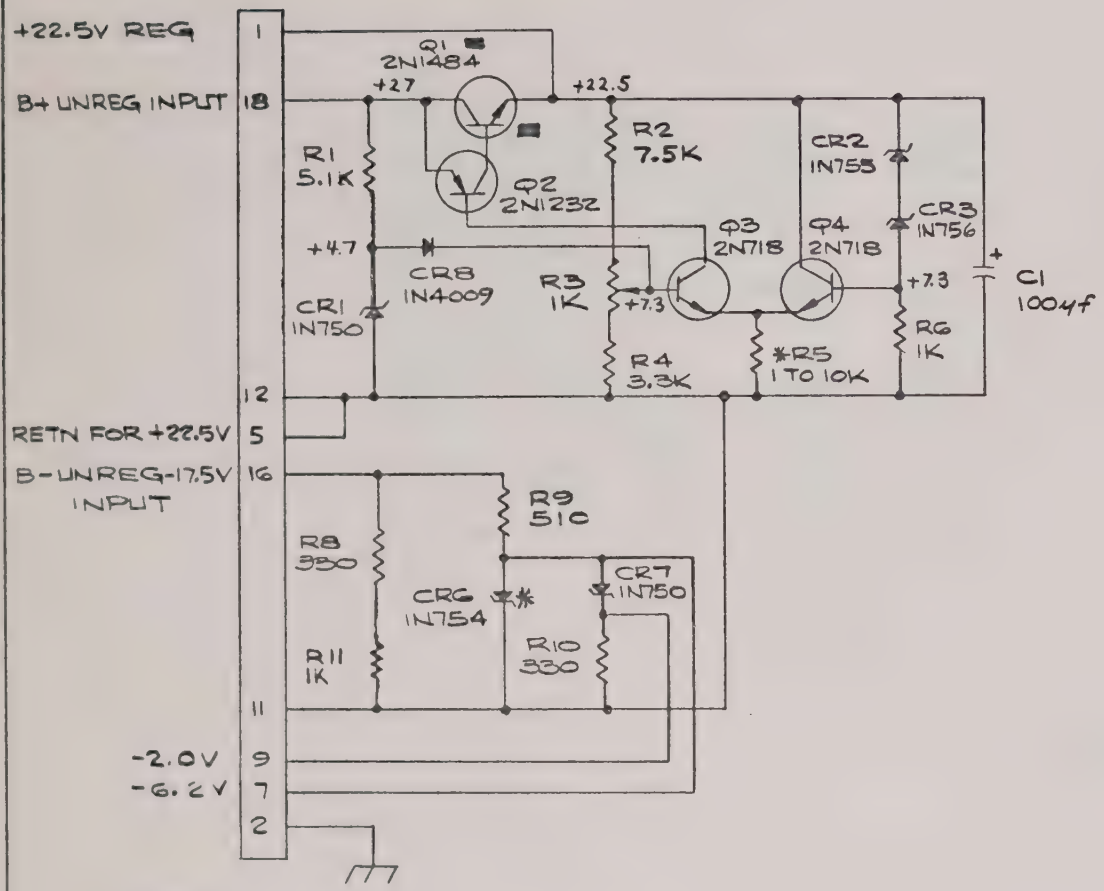
NOTE :
SCHEMATIC : B100,049



REAR VIEW

DRANETZ ENGINEERING LABS INC PLAINFIELD N.J.				
LAYOUT SQUARING AMPLIFIER				
DWN BY: DB	CHKD BY: DB	B SIZE	100,134	A REV
APPD BY: DB	DATE 1/17/64			

REV	DESCRIPTION



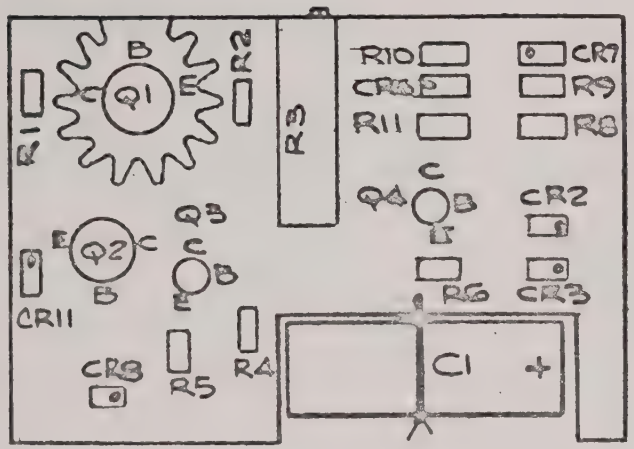
NOTES:
1. FOR ASSEMBLY DWG SEE B100,038.
2. RESISTORS ARE 1/4 WATT 5%
3. * INDICATES SELECTED COMPONENT
4. ■ INDICATES HEATSINK REQD

DRANETZ ENGINEERING LABS INC.
PLAINFIELD N.J.

SCHEMATIC DIAGRAM REGULATOR FOR POWER SUPPLY

DWG BY	CKD BY			
APP'D BY	DATE 9/19/63	B SIZE	100,051	A ISSUE

REV	DESCRIPTION



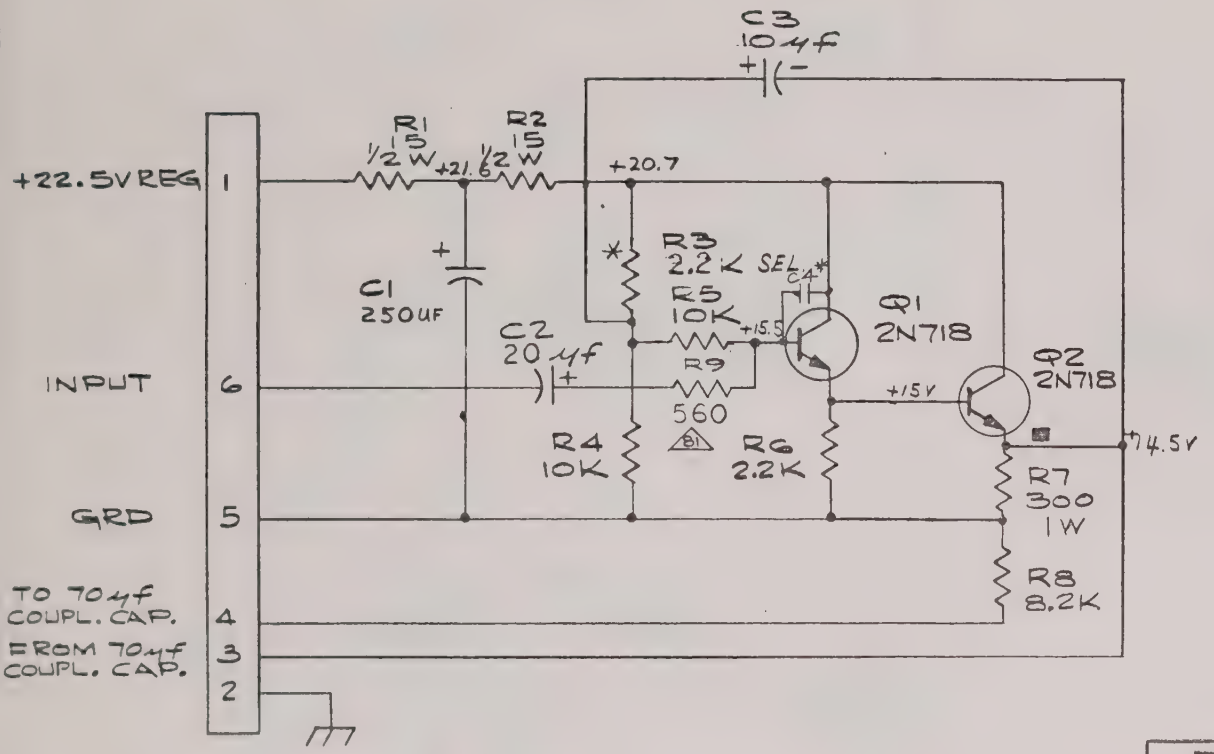
NOTE:
SCHEMATIC : B100,051

DRANETZ ENGINEERING LABS INC
PLAINFIELD N.J.

LAYOUT
REGULATOR

DWN BY:	CKD BY:			
APPD BY:	DATE 11/7/64	A	100,135	A

LET.	DESCRIPTION
B	ALL UNITS SERIAL#19 & FOLLOWING ADD R9 NOTE: THIS CHANGE SHOULD BE MADE ON ALL PRIOR UNITS



NOTES:

1. UNLESS OTHERWISE SPECIFIED: ALL RESISTORS ARE 1/4 WATT ±5%.
2. FOR ASSEMBLY DWG SEE B100,036
3. ■ INDICATES HEAT SINK REQD FOR COMPONENT.

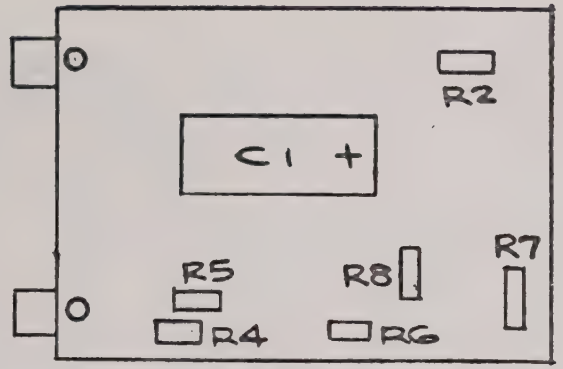
DUPLICATED FOR VAULT	
ISSUE	DATE
B	1-6-64

DRANETZ ENGINEERING LABS, INC.
PLAINFIELD N.J.

SCHEMATIC DIAGRAM OF POWER EMITTER FOLLOWER

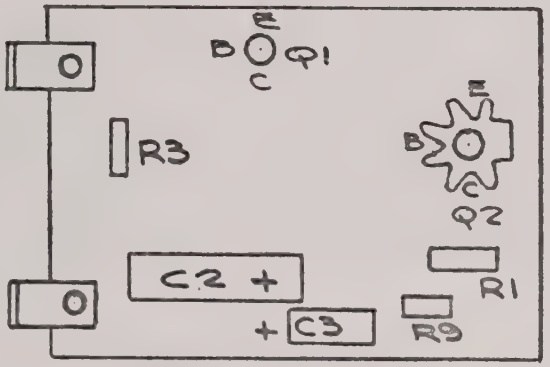
DWG BY	CHD BY			
JB		B	100,046	B
APPD BY	DATE	SIZE		ISSUE
JB	9/19/63			

REV	DESCRIPTION



TOP VIEW

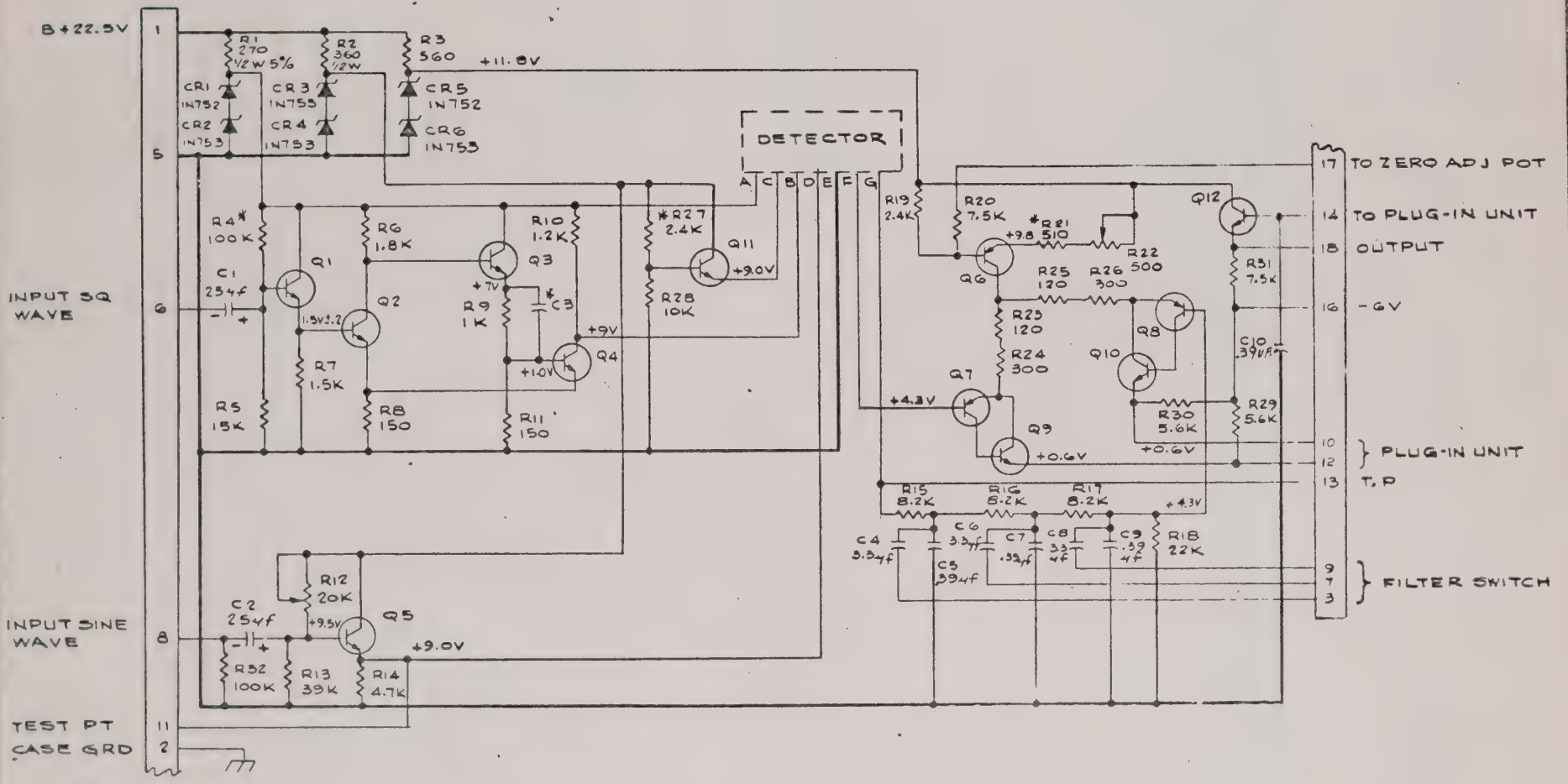
NOTE:
SCHEMATIC: B100,046



REAR VIEW

DRANETZ ENGINEERING LAB INC PLAINFIELD N.J.				
LAYOUT POWER EMITTER FOLLOWER				
DWN BY:	CKD BY:	A	100,136	A REV
APPD BY: AB	DATE 11/7/64			

REV	DESCRIPTION	APPD
B	R23 WAS 200Ω, R21 ADDED 510Ω EFFECTIVE SERIAL NO.	



NOTES:
1. FOR ASSEMBLY DWG SEE B100,609
2. ALL RESISTORS ARE 1/4 WATT 5% UNLESS OTHERWISE SPECIFIED
3. * INDICATES SELECTED COMPONENT
4. UNLESS OTHERWISE SPECIFIED ALL TRANSISTORS ARE 2N2221 OR 2N3855A
5. ALL PNP TRANSISTORS ARE 2N3638 OR 2N3251 (Q8, Q7, Q9)

DRANETZ ENG LABS INC
PLAINFIELD N.J.

SCHEMATIC DIAGRAM
RESOLVER CIRCUIT

DWN BY	CHKD		
4-8-66			
APPD	DATE	C	100,607 B

DRANETZ
ENGINEERING
LABORATORIES
INCORPORATED
2385 SOUTH CLINTON AVENUE, SOUTH PLAINFIELD, N J 07080

TWX 710-997-9553
Tel. (201)755-7080

WARRANTY

All Products of Dranetz Engineering Laboratories, Inc., are warranted against defective material and workmanship for a period of one year from the date of delivery. Dranetz Engineering Laboratories, Inc. will repair or replace all defective equipment returned to it during the warranty period, without charge provided there is no evidence that the equipment has been mishandled or abused.

Before returning any equipment under warranty: Check with factory representative for special instructions.

RETURNED MATERIAL AUTHORIZATION

NOTE: This completed form must accompany shipment. Date _____

Date of original purchase: month _____ year _____ Original P.O. No. _____

Customer ship Prepaid to:

Dranetz Engineering Laboratories, Inc.
2385 South Clinton Avenue
South Plainfield, N.J. 07080

Return to:

_____
_____
_____

Ship via _____

Description of returned instrument:

Model No. _____ Serial No. _____

Model No. _____ Serial No. _____

Reason for return (specify malfunction in detail)

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Telephone No. _____ Signature _____

Complete and exact malfunction information will expedite return of unit

CATALOG G

DRANETZ

PRECISION INSTRUMENTATION for

PHASE/GAIN

IMPEDANCE

CURRENT

VOLTAGE

QUALITY FACTOR Q

TIME/FREQUENCY

POWER LINE DISTURBANCE

INTRODUCTION

DRANETZ ENGINEERING Laboratories, Inc. is a leader in the design and manufacture of precision AC test instruments and systems. This equipment is widely used for measurement of impedance, admittance, transfer function, voltage, current and phase.

THIS CATALOG contains complete descriptions and specifications on many Dranetz instruments. With current price lists, this information is sufficient for specifying and ordering equipment. Additional information is often available, including application notes as well as Bulletins describing specific instruments and systems. These can be obtained by contacting our main plant or your local field representative.

DRANETZ EQUIPMENT utilizes the latest developments in the electronics state-of-the-art to provide the most advanced equipment with high quality at an economical price. Each instrument utilizes the latest in solid state and microcircuit components and, where possible, uses modular design. Flexibility and versatility are designed into these instruments at their concept. Computer compatibility is often available in standard instruments, and options can be provided for special requirements. In addition, the plug-in concept of these instruments assures exceptional flexibility.

OUR HIGHLY TRAINED FIELD AND PLANT ENGINEERS are readily available to assist you or supply you with additional information to enable you to meet your specific requirements. A telephone call will bring this service to you immediately without cost or obligation.

AFTER SALE SERVICE is an important reason for purchasing Dranetz equipment. Each instrument is warranteed for 1 full year after purchase. Dranetz maintains technical field representatives throughout the U.S. and in other countries, fully backed by in-plant experts. Wherever possible, application and service problems are solved on site. In addition, the company provides prompt and immediate service for equipment returned from the field. Frequently loan equipment is available for use during equipment repair.

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HV Stepdown Transformers
Current Transformers

For information on products assigned Federal Stock Numbers (FSN) or available on Federal Supply Schedules (GSA) please contact factory.

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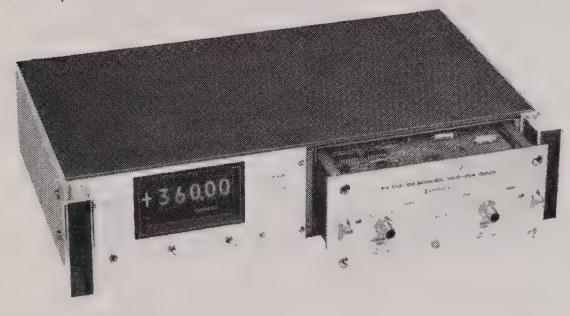
SERIES 305

SUPER PERFORMANCE PHASEMETERS AND GAIN/PHASEMETERS*



305 Series Phasemeters provide the highest available accuracy, along with many operational features. Designed for the calibration laboratory, the design engineer's bench, the production line and automatic test systems, the 305 is the most widely accepted phasemeter in industrial, and governmental organizations. **

FEATURES

- No hands 86 dB dynamic range
- Automatic or programmable operation and calibration
- Highest accuracy — to 0.03°
- Repeatability better than 0.01°
- Rejects harmonics and noise
- Wide frequency range — 1 Hz to 11 MHz

FLEXIBILITY THROUGH PLUG-IN CONCEPT

The plug-in concept of the 305 offers a wide selection of characteristics. Three standard mainframes and nine plug-ins are complemented by a variety of options, such as programmability, high speed and auto-calibration. Special modifications are also available. In addition, modular construction throughout provides maintainability at both component and P.C. card levels for ease and speed of servicing.

WIDE FREQUENCY RANGE

The basic mainframe provides a direct frequency coverage of 2 Hz to 700 kHz with high accuracy. By the use of frequency converting plug-ins such as the 305-PA-3005, standard units can handle frequencies up to 11 MHz. Special units can be provided for higher frequency.

NO HANDS OPERATION

The Series 305 Phasemeters require no controls or adjustments by the operator. These units are also equipped with several significant automatic features. These include automatic selection of angle range, automatic sensing of leading or lagging angle, automatic selection of the output time constants, and automatic setting of AC gains.

HIGHEST ACCURACY

Accuracy to better than ±0.03° is attained with precision mainframes and carefully designed plug-ins. Mainframes exhibit precise zero crossing detection, angle-to-DC conversion linearity to approximately ±0.01° and outstanding DC stability. Plug-ins are designed for accurate conversion of sine wave (also square wave) inputs to square waves through carefully controlled amplifier circuitry, use of gain autoranging, and harmonic filters where necessary.

INSENSITIVITY TO INPUT LEVEL

Series 305 plug-ins are available with a guaranteed accuracy of better than ±0.05° even with independent input level variations of 60 dB. Typical accuracy can approach ±0.03° as shown on the following page.

NON-AMBIGUOUS ANGLE READINGS

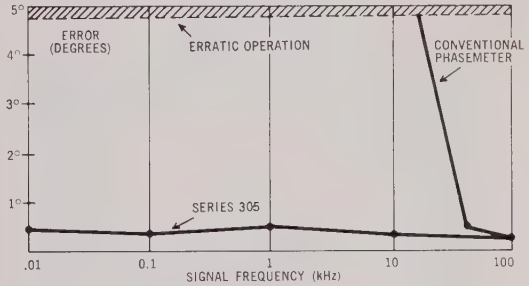
Two phase angle ranges in the 305 eliminate the ambiguity or "dead zone" error inherent in all other phasemeters (usually at 0°/360° or −180°/+180°). An automatic system switches to the 0°/360° range for angles near 180° and to the −180°/+180° range for angles near 0°. Unique guard bands prevent dead zones near switching points.

REPEATABILITY, STABILITY, AUTOCALIBRATE

Repeatability of the 305 is better than ±0.005°; temperature coefficient is ±0.001°/°C; and DC output drift is better than ±0.05° over any 30 day period. The autocalibrate feature eliminates virtually all DC errors in digital panel readout and BCD rear panel outputs.

NOISE IMMUNITY

Unique patented circuitry minimizes noise errors and makes possible accurate phase measurements under noise levels where other phasemeters become completely useless. The accompanying curve compares the phase error of the model 305 with that of a conventional phasemeter with broad band noise in both channels.



PHASE READING ERROR VS SIGNAL FREQ. FOR GAUSSIAN NOISE (FLAT TO 5 MHz) IN BOTH CHANNELS FOR S/N = 10

PROGRAMMABLE OPERATION

Standard mainframes are provided with rear connections for over-riding the automatic time constant and angle range selectors by relay contact closures. Options are provided for control by DTL and TTL logic.

DIGITAL READOUT

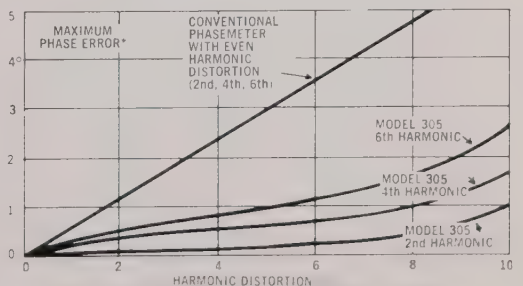
In addition to analog DC output, standard mainframes are available with up to 5 digit panel readouts (i.e., 0.00° to ±180.00° and 0.00° to +360.00°) and BCD outputs for each digit. Autocalibrate feature eliminates virtually all meter drift and scaling errors.

RAPID PHASE NULLING

For production testing of filters and other networks, an additional analog deviation-panel meter (305D) provides an easy means of adjusting a test angle to any accurate value. Presetting can be done in seconds without any other equipment. The precision digital panel meter monitors actual test angle continuously.

ABILITY TO REDUCE HARMONICS

The 305 is designed to reduce significantly the errors due to even harmonic distortion without the use of filters. The accompanying curve compares the error due to even harmonic distortion (maximized for worst case harmonic angle) on conventional phasemeters and on the model 305. (Odd harmonics in-phase with fundamental contribute no error.)



COMPARISON OF ERRORS DUE TO EVEN HARMONIC DISTORTION
(* For worst case phase relationship between harmonic and fundamental

*Manufactured under U.S. Pat. No. 3,725,781

**For extensive application information, write for availability of Applications Handbook of Precision Phase Measurement."

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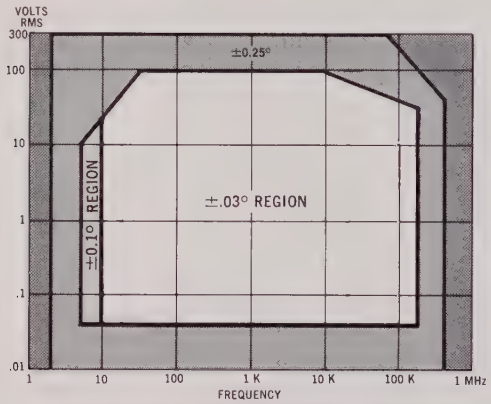
SERIES 305

HIGH PERFORMANCE PLUG-INS

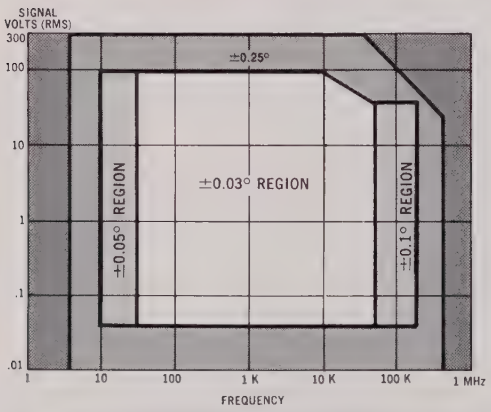
The variety of plug-ins available provides unlimited flexibility for the Series 305 Phasemeters in meeting many phase measurement problems. In addition to an expanding line of standard plug-ins, custom units can be designed for special needs.

305-PA-3001 AUTORANGING PLUG-IN

This plug-in features high accuracy over a broad range of input levels and frequencies. Autoranging of gain in each channel assures high accuracy (±0.05° guaranteed) over a dynamic range of 60 dB (50 mV to 50 V rms) for independent levels of inputs, with a useful range of 90 dB (10 mV to 300 V rms). This plug-in covers the range from 2 Hz to 700 kHz, with its highest accuracy in the 50 Hz to 50 kHz range. The curves shown illustrate typical accuracies as a function of level and frequency. The 305-PA-3001 also features compatibility with Textronix probes and includes front panel lamps to indicate when either input signal is below 50 mV or above 50 V rms.



TYPICAL ERROR CONTOURS FOR 305 w/305-PA-3001 FOR EQUAL SIGNAL INPUTS



TYPICAL ERROR CONTOURS FOR 305 w/305-PA-3001 FOR UNEQUAL INPUTS — REF. 0.3 VOLTS RMS

While the above accuracies apply to sine wave inputs, this instrument can also be used for square wave and amplitude modulated signals.

305-PA-3002 SINGLE RANGE PLUG-IN

The 305-PA-3002 is similar to the model 305-PA-3001 except that it does not include autoranging or limit indicator lamps. For sine wave inputs the standard unit is designed for guaranteed ±0.05° accuracy (typically ±0.03°) over independent signal levels of 50 mV to 500 mV rms, with a slight reduction in accuracy from 10 mV to 3 V rms. Other level ranges can be supplied on special order; Tektronix probes can be used for high input levels. This plug-in is useful for sine wave, square wave and amplitude modulated signals.

305-PA-3005 HIGH FREQUENCY PLUG-IN

This high frequency plug-in is designed for high accuracy to 11 MHz. Using a self tracking oscillator, the input signals are converted to 40 kHz for precision measurement by the mainframe. Input attenuators (50 ohms) are provided with 10 dB steps, to cover a range of 1 mV to 3 V rms in either channel. Front panel lamps indicate when input levels are out of range or when level controls are improperly set. The self tracking oscillator can be controlled by channel A signal or by a third independent signal.

305-PA-3007 PROGRAMMABLE AND AUTORANGING PLUG-IN

This programmable plug-in features all of the characteristics of the model 305-PA-3001. In addition it includes increased input gain to achieve operation down to 1 mV rms. The unit can be operated either in an automatic or programmable mode. Without rear connections, the plug-in operates automatically as a 305-PA-3001; however, by utilizing rear connectors, the internal autoranging can be over-ridden and additional internal gain can also be inserted. Programming is available by DTL and TTL logic.

305-PA-3008 SINGLE FREQUENCY PLUG-IN

The 305-PA-3008 is a special purpose plug-in designed for precision calibration of 50 Hz, 60 Hz and 400 Hz power line equipment such as wattmeters, phase detectors and watt hour meters. This instrument can measure phase difference between two voltages, two currents or between a voltage and a current. The unit covers a voltage range of 25 V to 250 V rms and a current range of 0.1 to 5 A rms. The basic plug-in covers the frequency range of 50 Hz to 500 Hz. Plug-in filters, available for 50 Hz, 60 Hz and 400 Hz, assure reduction of second harmonic by at least 40 dB and higher harmonics by at least 50 dB. A front panel zero control provides adjustment for high accuracy (±0.1°) at any single frequency.

305-PA-3009 WIDE BAND NETWORK ANALYZER PLUG-IN (GAIN/PHASE/AMPLITUDE)

This plug-in measures the voltage amplitude of each signal input (in volts or dBV, selectable by operator), the phase difference between inputs, and the amplitude ratio of inputs. Featuring auto-ranging of gain in both channels, it requires no manual setting of gains for any measurement. Simultaneous DC outputs on mainframe are proportional to all four fuctions. A front panel switch selects the measuring mode for digital panel readout — channel A voltage, channel B voltage, phase difference, or amplitude ratio. Lamps on the front panel of the plug-in indicate the proper decade multiplier. The 305-PA-3009A is designed for extending the low frequency range.

305-PA-3010 SPECIAL PURPOSE PLUG-IN

This plug-in is typical of special purpose plug-ins which can be supplied to meet unique problems. Having high input impedance, it is equipped with closely matched low pass filters to pass 125 Hz signals while rejecting 400 Hz signals, solving problems in many types of servo control systems. Similar units can be readily designed for other special voltage and frequency applications.

305-PA-3015 PROGRAMMABLE PLUG-IN

Intended for use in automatic test systems, this plug-in has two selectable filters for harmonic rejection and selectable gains to handle inputs from 50 mV to 50 V rms. Filter (or filter out) selection as well as gain switching is accomplished by contact closures across terminals on the rear of the main frame.

PRECISION TRANSFORMER ISOLATION NETWORKS

Dranetz TR 3100 series networks are available for input voltage isolation with minimum phase error and flat gain response. For use with balanced or signal ended sources, these units are equipped with internal preamplifiers to produce outputs in the 30 mV to 3 V rms range (for use with 305 Series Phasemeters) for input levels from 50 mV to 500 V rms. These transformer units are packaged for direct plug-in into the input BNC's of the phasemeter, and draw B+ power from the front panel accessory connector of the phasemeter plug-in. Size: 2¾" x 2¾" x 2". Input: banana jack. Output: BNC.

Model TR—	Zin	Com. Mode Rej: >60 dB for frequency	Range for ±0.1° typical shift	Range for ±0.3° typical shift	Gain ±2%
3101	1 megΩ 70 pF	Below 1 kHz	20-400 V rms 50 Hz-20 kHz	5-400 V rms 10 Hz-25 kHz	x 0.01
3102	100 kΩ 70 pF	Below 10 kHz	2-40 V rms 50 Hz-20 kHz	0.5-40 V rms 10 Hz-25 kHz	x 0.1
3103	10 kΩ 70 pF	Below 25 kHz	0.2-4 V rms 50 Hz-20 kHz	0.05-4 V rms 10 Hz-25 kHz	x 1.0

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SERIES 305
HIGH PERFORMANCE PHASEMETERS

MAINFRAME SPECIFICATIONS

Frequency Range: 2 Hz to 11 MHz (see plug-in data)

Angle Ranges: 0.00° to ±180.00° or 0.00° to +360.00° manually or automatically selected. End-of-range measurement errors are prevented by 15° automatic guard zones.

Analog Output

Range: −1.8000 to +3.6000 Vdc corresponding to measured angle; 10.0 mVdc per degree

Accuracy: See plug-in specifications

Output Impedance: 100 ohms

DC Resolution: Infinite

Linearity: Approx. ±0.01°

Repeatability: Better than ±0.005°

Time Constants: Automatically selected; 10 ms for frequency >5 kHz, 50 ms >500 Hz, 350 ms >50 Hz, 700 ms >2 Hz (Note: 4.6 time constants to respond to better than 99% of step change).

Warm-up Drift: Approx. 0.05° after first minute.

Long Term Drift: Typically less than ±0.05° per month

Temp. Coefficient: Approx. ±0.001°/°C

Recommended Output Devices: Recorders, DVM's, A-D Converters, Printers

Self Check: Front panel switches; dc outputs correspond to −180.00°, 0.00°, +180.00° and +360.00°

Error Rejection: False triggers due to high frequency noise are locked out for signal to noise ratios better than 10:1. Errors and fluctuations due to waveform dissymmetry or low frequency noise reduced by at least 10 to 1.

Harmonic Rejection: Worst case errors due to even harmonic distortion reduced by approximately 5:1 without filters. Odd harmonics in-phase with fundamental contribute no error.

Operator Adjustments: None.

Operating Temp. Range: 0° to +50°C

Grounding: Independent grounds for signal, chassis, and power line. (For safety, chassis and power line grounds connected at factory.)

Remote Programmability (standard on all mainframes): By rear connector pins. Over-ride by contact closure of automatic time constant selection and angle range. Factory installed wiring from rear connector to plug-in for use with programmable plug-ins.

Modular Construction: Circuits on removable plug-in cards, extenders supplied for ease in servicing.

Size: 3½″ high, 16″ deep, 19″ rack/portable package.

Weight: 20 lbs; shipping 30 lbs.

Power: 115/230 V, 50-400 Hz, <0.75 A (specify voltage and frequency when ordering).

Plug-In Accommodation: Accepts 305-PA-( ) plug-ins. Mainframes and plug-ins are interchangeable.

ANGLE PRESENTATION

	Model 305	Model 305B	Model 305C	Model 305D
DIGITAL				
Display	None	4 digit plus sign	5 digit plus sign	
Angle Ranges	Not Applicable	0.0° to ±180.0° and 0.0° to +360.0°	0.00° to ±180.00° and 0.00° to +360.00°	
Resolution	NA	0.1°	0.01°	
BCD Output	None	BCD coded (1248), 4 lines per digit plus polarity line; TTL/DTL compatible (<0.8 V to > +2.4 V dc). Read and hold on command, and data ready features available on rear connector.		
Warm-up Time	NA	30 minutes (1 minute with option 107)		
Zero & FS Controls	NA	Front panel for FS & 0 (no adjustments with option 107)		
ANALOG				
DC Output	10.0 mV/°; 0.0000 V to 3.6000 V and −1.8000 V to +1.8000 V corresponding to 0.00° to 360.00° and −180.00° to +180.00°; infinite resolution.			
DC Offset	None			Continuously adjustable angle offset. Analog panel meter and DC output indicate deviation from offset.

OPTIONS

#101 Rear connectors for signal and reference inputs, BNC[4]

#102 Full mainframe programmability; includes self check, angle range and time constant selection, DTL and TTL compatible.

#103 High speed analog output response. Time to respond to within 99% of step change: 1 ms for frequency >5 kHz, 10 ms >500 Hz, 100 ms >50 Hz, 1 second >5 Hz. (Temp. stability ±0.01°/°C)
(Opt. 103 not available with Opt. 107 below)

#107 Automatic calibration checks and automatically readjusts digital readout and BCD output circuits and at 0° and 360° to reduce readout errors to ±0.01°. This option available only on 305C.

COMBINED PLUG-IN AND MAINFRAME SPECIFICATIONS

MODEL	FREQUENCY RANGE	INPUT LEVELS (independent)	INPUT Z	ACCURACY[2] WITH INDEPENDENT LEVELS UNLESS OTHERWISE INDICATED Analog output accuracy: As specified below. Digital phase accuracy: For model 305C, same as analog accuracy. For model 305B, add ±0.15° digital readout error to analog accuracy specified.
305-PA-3001 Auto Ranging Plug-in	2 Hz to 700 kHz	10 mV to 300 V rms up to 10 kHz and to 50 V rms up to 700 kHz; can be extended to 40 kV rms with Textronix probes. Each channel has automatic gain ranging, and lamps which indicate when level is below 50 mV and above 50 V rms.	1 megohm shunted with 40 pF	±0.05°, 50 mV to 50 V rms from 50 Hz to 50 kHz; typically ±0.03°, 50 mV to 50 V rms from 50 Hz to 50 kHz, ±0.05° to 10 Hz, ±0.1° to 250 kHz, and ±0.25° at other levels to 500 kHz.
305-PA-3002 Single Range Plug-in	2 Hz to 700 kHz	10 mV to 3 V rms[1]; can be extended to 3 kV rms with Textronix probes. Other ranges available on request.	1 megohm shunted with 40 pF	±0.05°, 50 mV to 500 mV rms from 50 Hz to 50 kHz; typically ±0.03°, 50 mV to 500 mV rms from 50 Hz to 50 kHz, ±0.05° to 10 Hz, ±0.1° to 250 kHz, and ±0.25° at other levels to 500 kHz.
305-PA-3005 High Frequency Plug-in	200 kHz to 11 MHz	1 mV to 3 V rms; manual level controls in 10 dB steps. Lamps indicate when inputs are out of range or when level controls are improperly set.	50 ohms	Broadband with equal inputs above 10 mV rms: ±0.4° from 200 kHz to 4 MHz; ±1° from 4 MHz to 11 MHz. With independent levels above 10 mV rms: ±1° up to 4 MHz and ±2° up to 11 MHz. Single frequency — above 10 mV rms: ±0.3° at any frequency from 200 kHz to 11 MHz at any fixed levels.
305-PA-3007 Programmable and Auto-Ranging Plug-in	2 Hz to 700 kHz	Auto-ranging: similar to levels of 305-PA-3001. Programmable: over-rides autoranging; extends low levels to 1 mV rms; DTL, TTL logic; program connector in rear of mainframe.	1 megohm shunted with 40 pF	Same as 305-PA-3001 for levels above 10 mV rms; typically ±0.35° from 50 Hz to 50 kHz for levels below 10 mV rms.
305-PA-3008 Power Freq. Plug-in	50-500 Hz without filters. 50 Hz, 60 Hz and 400 Hz L.P. filters available[3]	25 V to 250 V rms; 0.1 A to 5 A rms. Inputs are transformer isolated.	100 k ohm (voltage) 1 Ω max. (current)	At any single frequency, with filter set: ±0.1°, 25 V to 250 V rms, or 0.1 A to 5 A rms.
305-PA-3009 Network Analyzer (Gain/Phase/ Amplitude)	5 Hz to 700 kHz (Note: 305-PA-3009A operates to 1 Hz with 305 mod. 14	10 mV to 40 V rms. Each channel has automatic gain ranging. Direct reading of phase angle, amplitude ratio and level of each input. Compatible with Tektronix probes.	1 megohm shunted with 40 pF	Phase: ±0.1° from 40 mV to 40 V rms from 50 Hz to 50 kHz; typically ±0.25° at all other levels from 5 Hz to 500 kHz. Voltage Amplitude: above 40 mV (channel A or B): ±2% reading ±0.03% FS, 50 Hz to 50 kHz; ±5% reading ±0.03% FS, 100 kHz to 500 kHz.[5] Ratio: ±0.5 dB, 50 Hz to 50 kHz; ±1 dB, 50 kHz to 500 kHz.[5]
305-PA-3010 Special Purpose Plug-in (with filter)	For use at 125 ±10 Hz; matched filters in both channels reject higher frequencies	500 mV to 5 V rms. Other ranges available on request.	1 megohm shunted with 40 pF	±0.1°, 500 mV to 5V rms; ±0.25°, 100 mV to 500 mV rms.
305-PA-3015 Selectable Filter Plug-in	5 Hz to 500 kHz without filters; uses 2 of type 305-PA-3008-( ) filters [3]; filter selection programmable	Ranges of 50-500 mV rms, 0.5 to 5 V rms, and 5-50 V rms selectable by remote contact closures.	1 megohm shunted with 40 pF	With filters, ±0.1° at fixed frequencies over all levels; without filters ±0.1° from 50 Hz to 50 kHz at all levels (typically ±0.03°), typically ±.25°, 5 Hz to 500 kHz.

[1] Can be provided for other voltage levels.

[2] For sinusoidal signal; can be used for square wave inputs over limited frequency range; can be used for amplitude modulated signals up to 97% modulation, depending upon model, level and frequency.

[3] 50 Hz filter, P/N 305-PA-3008-50; 60 Hz filter, P/N 305-PA-3008-60; 400 Hz filter, P/N 305-PA-3008-400. (Other frequencies available on request

[4] Available for use with 305-PA-3001, -3002, -3007 and -3010. Specify when ordering plug-in.

[5] For higher accuracy below 50 Hz, specify Model 305-PA-3009A.

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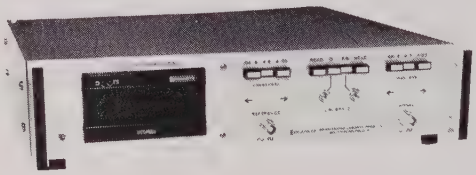
SERIES 331

HIGH ACCURACY ECONOMY PHASEMETERS



- Accuracy to 0.05°, resolution to 0.01°
- Frequency range 2 Hz to 700 kHz
- Analog output and 4 or 5 digit panel readouts
- Input 0.05 to 220 V rms
- Accepts sine, square and other waveforms in either channel

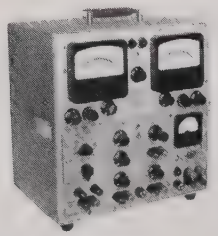
The Dranetz 331 Series Phasemeters feature high accuracy over a broad amplitude and frequency range. Front panel controls (equipped with LO/HI indicators) are used to select proper voltage ranges, as well as to check and adjust calibration. The 331 incorporates several of the important features of the Superperformance 305 Series, including elimination of 0°/360° ambiguity and reduction of sensitivity to noise and even harmonics. The 331 is designed for calibrating equipment, for testing subassemblies and for general laboratory work.

SPECIFICATIONS

CHARACTERISTICS	331B	331C
Frequency Range:	2 Hz to 500 kHz	
Accuracy: Sine Wave:	±0.1° ±1 digit from 50 Hz to 50 kHz, ±0.2° per 100 kHz to 500 kHz and ±0.2° ±1 digit at 5 Hz.	±0.05° from 50 Hz to 50 kHz; ±0.2° from 10 Hz to 100 kHz; add ±0.2° per 100 kHz above 100 kHz.
Square Wave:	±0.1° ±1 digit from 10 Hz to 20 kHz; ±.5° per 100 kHz above 20 kHz	±0.05° from 10 Hz to 5 kHz; ±0.1° to 20 kHz; ±0.5° per 100 kHz above 20 kHz.
Angle Ranges:	000.0° to 360.0° or −180.0° to +180.0° automatic or selectable.	
Display:	Beckman (Sperry) 0.6″ 4 digit for ranges above.	Beckman (Sperry) 0.6″ 5 digit for ranges above.
Drift (30 day period): Sine Wave: Square Wave: DC Drift:	None None 0.1°	
Repeatability (DC):	Better than 0.1°.	Better than 0.01° after readjusting 0 and FS.
Temperature Coefficient:	0.01°/°C independent of other conditions.	
Input Signal Amplitudes:	0.05 to 220 Volts rms in 3 ranges (0.05-0.5, 0.4-5, 4-220; can be extended with Tektronix probes.	
Input Impedance:	1 megohm shunted by 50 pF nominal	
Response Time:	700 milliseconds	
Maximum DC Component:	±200 volts; can be extended with probes	
Analog Output:	0.0000 to 3.600 V and −1.8000 to +1.8000 V DC, +10.00 mV DC/degree phase; output impedance less than 100 ohms.	
Ambient Temperature	0°C to 45°C	
Panel Controls and Adjustments:	3 range input level pushbuttons each channel; read-hold; power; 0° cal and 360° cal adjustments.	
Connectors:	BNC, both input channels, rear and front; PC rear for analog output.	
Power Requirements:	105-125 or 210-250 volts, 50/60 Hz, 70 watts.	
Dimensions:	3½″ high x 16″ deep, 19″ rack/portable package, 18 lbs. (7 kg) net wt., 25 lbs. (10 kg) shipping.	
Option:	#101: BCD output, TTL/DTL, 8421	#101: BCD output, TTL/DTL, 8421

SERIES 100 NETWORK ANALYZER

COMPLEX IMPEDANCE, ADMITTANCE AND TRANSFER FUNCTION METERS



MEASURE... RECORD... PLOT...

$$Z = R + jX = |Z| \angle\theta z \qquad Y = G + jB = |Y| \angle\theta y$$

$$\frac{V_0}{V_1} = \left|\frac{V_0}{V_1}\right| \cos\theta + j \left|\frac{V_0}{V_1}\right| \sin\theta = \left|\frac{V_0}{V_1}\right| \angle\theta$$

These instruments provide rapid measurements of impedance, admittance and transfer function parameters. Panel meters give direct reading, and DC outputs are used for frequency plots. Consisting of 100C main frame and choice of plug-in, the instrument is exceptionally flexible. Plug-in 100-PA-1001A is used for both impedance and admittance measurements. 100-PA-1008 is for differential admittance measurements, to improve accuracy of minor components.

APPLICATIONS

- Production Testing
  Capacitors, inductors, transformers
- Linear Network Design
  Filters, amplifiers, linear IC's
- Acoustic and Electromechanical Analysis
  Transducers, arrays, interacting fields
- Linear and Non-linear Device Design
  Piezoelectric, dielectric, magnetic devices

PLUG-INS

Model 100-PA-	Measures	Frequency Range	Linear Ranges, Full Scale 1, 2.5, 5, etc. Sequence	Voltage Across or Current Through Unknown (RMS)
1001A	Z & Y	100 Hz to 200 kHz	10 Ω to 50 kΩ 10 μ℧ to 50 k μ℧	0-45 mV in Z mode; 3 V in Y mode
1008	Y or △ Y*	100 Hz to 100 kHz	100 μ℧ to 500 m℧	3 V

For further details on Series 100 write for bulletin 100, Tech. 1, and Tech. 3.
Patents #3,267,355 and #3,275,933.

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SERIES 325

POWER SYSTEM POLYMETER / DUAL MEASURE OF VOLTAGE, CURRENT, TIME, FREQUENCY

FEATURES

- Simultaneous measurement and display of two selectable parameters.
- Display of continuous, triggered or maximum readings.
- Full isolation of all inputs.
- Precision measurement of time interval in seconds or cycles.
- Large 0.6″ digital display.
- Precision frequency measurement optional.
- Portable for field use.
- A field instrument with laboratory accuracy.

The Series 325 is specifically designed for measuring key parameters in electric power systems. Simultaneous measurements of Voltage and Current, 2 Currents, 2 Voltages, Current and Time, and Voltage and Time may be made. Readings may be taken on a continuous basis, or the meter may be triggered to "freeze" readings at a specific time. Time may be measured either in seconds or cycles of the power line frequency. Timing and trigger inputs may be actuated from type A or B dry contacts or by AC or DC voltages. Special circuits assure positive triggering on first contact and prevent simultaneous start/stop conditions. Options and adapters are available for DC current, DC voltage, fast frequency measurement, low pass filters and BCD outputs.

APPLICATIONS

- Ideal for electric utility use.
- Testing of trip points on overcurrent, overvoltage, undercurrent, undervoltage, and underfrequency relays.
- With Model 314 Phase Angle Meter, ideal for impedance relays.
- Precision measurement of frequency.

SPECIFICATIONS

Frequency Range: 47-450 Hz. (25 Hz available on request.)
AC Voltage: 15 mV to 1000 V RMS, 1.5, 15, 150, 1000 V FS, transformer isolated, 5000 ohms per volt.
AC Current: 1.5 mA to 100 A RMS, 0.15, 1.5, 15, 100 A FS, transformer isolated, .001 ohms insertion resistance.
Time Interval (2 ranges): 0 to 999.99 seconds in .001 second increments. 0 to 9999.9 cycles in 0.1 cycle increments.
Trigger Inputs: (Start and Stop) Contact closure, DC step voltage change, or AC input.
Accuracies: V, I, ±0.3% reading ±0.03% FS; Time, ±0.003% reading ± last digit.
Out of Range: Display blinks when level is too high.
Measurement Modes: Continuous, triggered, and "hold maximum."
Dielectric Test: 4250 V RMS to ground from V and I terminals. 1600 V RMS to ground from trigger terminals. (Per ANSI-C39.5.) Also meets SWC test.
Power Supply: 95 to 140 or 190 to 280 V RMS, 47 to 450 Hz, 20 watts, International Universal type connector.
Operating Temp. Range: 0°F. to 125°F.
Case: Portable, weatherproof, with cover 11″L x 7″W x 9½″D (28cm L x 18cm W x 24cm D); without cover 11″L x 7″W x 7″D (Panel 11″ x 7″).
Weight: 10 pounds. (Shipping weight, approximately 17 pounds.)

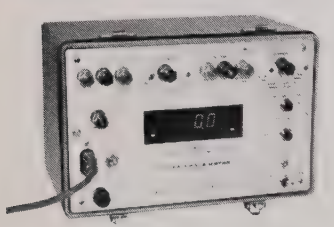
OPTIONAL FEATURES

Option 101: Fast frequency measurement capability — 0.1 sec. meas. time, 0.01 Hz resolution; 1 sec., .001 Hz resolution; accuracy ±0.002 Hz ± resolution.
Option 102: Low pass filters for removing effects of harmonics from measurements.
Option 103: BCD outputs suitable for driving printers for recording measured data. DTL/TTL compatible.
Option 105: True RMS detection.
Option 106: Panel mount.
Option 107: Panel mount with remote display.
Option 108: Accessory power for 325-PA-( ) adapters.
Option 109: Dry contacts corresponding to START/STOP times (available only when Option 108 is chosen.)
325-PA-1001: DC Current Adapter.
325-PA-1002: DC Voltage Adapter.
325-PA-1003: Contact Opening Trigger Adapter.
325-PA-1004: Adjustable Threshold Trigger Adapter.

FOR FULL INFORMATION AND DETAILED SPECIFICATIONS WRITE FOR BULLETIN 325 A

SERIES 314

POWER SYSTEM PHASEMETER / FOR ACCURATE & RAPID MEASUREMENT OF PHASE IN ELECTRIC POWER SYSTEMS



FEATURES

- Universal Current-Voltage Inputs, V-V, I-I, V-I
- Portable
- Immune to Harmonics
- Independent of Frequency Changes
- Digital Readout — "No Hands" Simplicity
- Accuracy ±0.5°, Resolution ±0.1°
- Independent of Input Levels
- Complete input isolation

APPLICATIONS

- Testing and Adjustment of Protective Relays
- Measuring Load Current Phase Angles — Measuring Power Factor
- Testing Polyphase Balance
- Determining Power Flow in Interconnected Systems
- Minimizing Circulating Reactive Currents
- Synchronizing Multiple Sources

Accurate, precise and rapid phase measurement is an essential technique in the setup, operation, and maintenance of modern power systems, subsystems, and the control and protection circuits used in them. The value of a phase meter in such applications is directly proportional to the speed, convenience, and validity with which it indicates the phase angles it measures. With the introduction of the Dranetz Model 314, virtually all of the limitations and error sources of electromechanical meters have been removed, and the overall accuracy of this class of phase measurements has been increased by more than a full order of magnitude. The basic accuracy of ±0.5° specified for the Model 314 is actually **maintained, without degradation,** over the wide ranges of frequency variation, voltage/current level, and harmonic content for which the instrument is rated. Furthermore, the direct-reading **digital** presentation of phase, to four-place resolution (0.1° increments) requires no interpretation or interpolation, and is not subject to reading errors or parallax. **The phase angle you see is the phase angle that exists — to within ±0.5°,** without correction or uncertainty.

SPECIFICATIONS

ELECTRICAL

Range: 000.0° to 360.0°, Direct-reading
Frequency Range: 47-53, 57-63 Hz (specify at time of ordering)
Input Current Range: (both input circuits) .015-50 A rms
Input Voltage Range: (both input circuits) 0.3 to 600 V rms
Current-Input Impedance: Approx. 2 or 20 milliohms
Display: Four digits, non-flickering, 0.6″ numerals
Resolution: 0.1°
Accuracy: ±0.5°
Burden:
Voltage: 1.8 VA max. at 600 V rms input
Current: Approx. 2.5 VA at 50 A rms input
Interaction Between Inputs: None
Errors Due to Harmonic Distortion: None for harmonic distortion up to 30%, any harmonic
Errors Due to Offground Inputs or Reversal: None
Overload:
Voltage: 100% overload for 1 minute
Current: 100 A rms for 1 minute
Dielectric Test: Up to 2200 Volts rms between inputs and ground (ANSI-C39.5)
Self-Check: Provided for 000.0°. Full scale (360.0°) is autocalibrated internally
Power Required: 115/230 V, 50-60 Hz, 20 Watts

MECHANICAL AND ENVIRONMENTAL

Case: Portable weatherproof carrying case with cover 11″L x 7″W x 9½″D (28cm L x 18cm W x 24cm D). Without cover 11″L x 7″W x 7″D. (Panel 11″ x 7″)
Operating Temperature Range: 10°F to 110°F
Weight: 10 pounds approx. (shipping wt. approx. 17 pounds)

FOR FULL INFORMATION AND DETAILED SPECIFICATIONS WRITE FOR BULLETIN 314A

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SERIES 606

POWER LINE DISTURBANCE ANALYZER/RECORDER

- For 115/230/460 V rms, 1 and 3 phase systems.
- Monitors, classifies, times and prints out line disturbances.
- Immediate and day-end printouts.
- Operates on command or disturbance — no wasted paper.
- For portable or permanent installation.
- 4 hour internal carry over power.

The 606 is designed specifically for monitoring power mains connected to computers, process control systems, hospital equipment and data communications devices, which are particularly susceptible to line transients, level changes or other disturbances. Using a digital microprocessor, the 606 classifies each disturbance into IMPULSE, CYCLE-TO-CYCLE CHANGE or SLOW RMS CHANGE. When preset thresholds are exceeded, the instrument prints out time, classification, magnitude, duration and channel designation. Data is also accumulated for overflow and day-end printout. The instrument is designed for unattended monitoring in a permanent installation or for temporary use at more than one site.

SPECIFICATIONS

Input Voltage Ranges: 115, 230, 460 V rms ±50%, all transformer isolated, Zin > 100 kΩ

Number of Inputs: Model 606-1, 1 input; Model 606-3, 3 inputs (3ϕ or separate circuits)

Test Modes:

AVG+ or AVG−: Increase or decrease in steady state rms, averaged over 10 sec

SURGE or SAG: Increase or decrease in cycle-to-cycle rms value

IMPULSE: 0-peak value of impulse (excluding line voltage waveform) having duration 0.5-100 μsec

ACCUMULATED COUNT: Summation of disturbance data in memory (includes time, HI AVG+, LO AVG−, HI SURGE and number of HITS, LO SAG and number of HITS, HI IMPULSE and number of HITS)

Printing Modes:

AVG+ or AVG−: Prints time, AVG+ or AVG−, rms VALUE, CHAN., when exceeding threshold of 2, 5, 10, 15 V rms*

SURGE or SAG: Prints time, SURGE or SAG, rms VALUE, CHAN. and duration (cycles) when exceeding threshold of 2, 5, 10, 20 V rms*

IMPULSE: Prints time, IMPULSE, 0-pk VALUE (excluding line voltage) and CHAN, when exceeding 0-pk threshold of 50, 100, 200, 400 V

SUPPLY DOWN or UP: Prints POWER OFF or POWER ON and TIME

STORED DISTURBANCES: Stores data on disturbances during printing. Prints out when printer clears

ACCUMULATED COUNT: (Short Term) Overflow of data entering printer. Prints out automatically

DAILY ACCUMULATED COUNT: End-of-day print out. Prints number of day and ACCUMULATED COUNT

TEST: Prints time and ACCUMULATED COUNT

RESET: Prints time and ACCUMULATED COUNT, resets memory

PRINT OFF: Prints PRINT OFF and TIME, disables printer, all data goes into accumulator for delayed summary printout

Accuracy:

AVG+ or AVG−: At 60 Hz (sine wave signal), ±1% of reading ±1% of nominal input

SURGE or SAG: At 60 Hz (sine wave signal), ±1% of reading ±1% of nominal input

IMPULSE: ±5% of reading ±1% of maximum impulse calibrated with a positive going, 10 μsec, half sinewave impulse. 6 dB bandwidth with half sinewave impulses: 100 μsec to 0.5 μsec

Clock: Indicates real time in hours, minutes, seconds, crystal controlled. During power off, operates on internal batteries (4 hours). Clock resets from front panel buttons

Printer: 17 character, alpha-numeric, thermal, paper 2¼" wide, prints 1 line/sec

Supply Power: 90 to 140 V, 45-450 Hz, 1ϕ, 1.0 A maximum

Case: Portable, aluminum, weatherproof, removable cover, equipped with carrying handle and feet

Size (with cover): 11"H x 7"W x 9½"D; net weight, 16 lbs.

Options: Opt. 101 (606-3 only), freq. disturbances; Opt. 102, supply power 230 V nominal, 45-65 Hz; Opt. 103 (606-3 with Opt. 101 only), monitors 400 Hz power lines

*These values for 115 V input; multiply by X2 or X4 for 230 V rms or 460 V rms.

MODEL K103 TEST KIT: Includes calibrated disturbance generator designed to verify operation of Series 606. Also includes a set of programmed memories containing checkout routines. Card puller and extender board are also included.

MODEL 910 UNINTERRUPTIBLE POWER SUPPLY: For line interruptions up to 4 hours, 606 itself prints power down and return times, maintains clock operation and retains accumulated data in memory. For complete operation of 606 during power shutdown up to 2 hours, use Dranetz Model 910 uninterruptible power supply.

CHARACTERISTICS: Nominal input 95-140 V rms, 47-450 Hz; size, 11" x 7" x 9½".

FOR FULL INFORMATION WRITE FOR BULLETIN 606A

SERIES 602

FREQUENCY SELECTIVE VOLTMETER

- Broad range — 2 kHz to 350 kHz.
- High selectivity — spurious signals down more than 50 dB.
- Battery powered — long life.
- Excellent for K and N carrier systems.
- Meets W.E. KS-15538-L5A

The Dranetz Model 602 Frequency Selective Voltmeter is a low power transistorized instrument for the measurement of carrier signals hidden among other multiple signals. The instrument uses a frequency selective detector based on heterodyning to cover a broad frequency range, and uses a crystal oscillator for frequency and level calibration. The instrument has both high impedance and bridging inputs for 135 or 600 ohms (balanced or unbalanced).

SPECIFICATIONS

Frequency Range: 2-350 kHz

Input Levels:
Full Scale Ranges: −60 to +20 dBm, 5 dB/step
Sensitivity: −70 to +22 dBm

Selectivity: Spurious output down more than 50 dB

Accuracy:
Level: 135 ohm input, ±.25 dB
600 ohm input, ±.5 dB
Calibrator: ±.25 dB at 35 kHz ±250 Hz
Frequency: ±1 kHz or ±500 Hz

Frequency Response: ±1 dB ref 25 kHz

Meter Bandwidth: Nominal 500 Hz at −3 dB, 1000 Hz at −60 dB

Audio Bandwidth: Nominal 2.5 kHz at −6 dB, 8 kHz at −60 dB

Internal Noise: At least 20 dB below full scale

Battery Drain: 80 mA nominal

Size: 11"L x 7"W x 9½"D (28cm L x 18cm W x 24cm D) with cover; panel 7" x 11"

Weight: Net 10 lbs., shipping 15 lbs.

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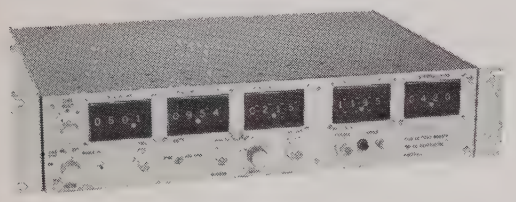
SERIES 206A

DIGITAL GATING/TIMING GENERATOR



Series 206A GATING/TIMING GENERATORS gate the output of an a-c signal generator and provides a single signal burst or repetitive signal bursts, with turn-on and turn-off times coincident with zero crossings of the input signal to minimize switching transients.

Internal or external triggering initiates an accurate sequence of pulses for: (1) turning on the signal at its first positive going zero crossing; (2) turning off the signal at the first positive going zero crossing following a precise time interval; (3) delayed triggering of oscilloscopes or other devices; (4) gating detectors or receivers after a precise time interval; (5) delayed triggering of Dranetz Series 215 AC Sampling Voltmeters or Series 202 CW/Pulse Vector Component Computer systems.

APPLICATIONS:

- Automatic a-c testing of components and circuits.
- Testing of data communications systems, modems, multiplexers and switching circuits.
- Calibration of underwater transducers under tone burst conditions.
- Measurement of propagation and reflections in acoustical fields.

FEATURES:

Wide frequency range of 50 Hz to 3 MHz.

Provides zero-crossing turn-on and turn-off of a-c signals, single or repetitive gating.

Provides three additional independently selectable timing pulses for controlling gated detectors and receivers.

Digitally-controlled timing from front panel controls.

Remote programming.

SPECIFICATIONS

MODES OF OPERATION:
CW
Gated: (for CW, FM or Phase-shifted signals).
Single shot or repetitive gating of AC signals.
Repetitive gating using internal timing oscillator (with or without sync. to 60 Hz power line).

SIGNAL CHANNEL:
Frequency range: 50 Hz to 3 MHz.
Input: — Sinusoidal signal, 1 V rms ±10%.
Impedance—10 kΩ shunted by 100 pF.
Output: Level — Adjustable from 0.1 to 1 V rms into 75Ω load over full frequency range; adjustable from 0.5 to 5 V rms into 10kΩ up to 2 MHz.
Distortion — Less than ½% from 50 Hz to 0.5 MHz; <1% to 3 MHz.
Input to output isolation: >60 dB to 0.5 MHz; noise typically 60 dB down.
Types of gating: Zero crossing turn on and zero crossing turn off; less than 1.5° or 25 nsec coincidence error. Non-synchronous turn-on and turn-off.

EXTERNAL TRIGGER:
Pulse or square wave input, ±5 V into 3 kΩ load, transformer input, rise time 50 μsec max, duration 50 μsec. min.

GROUNDING:
Separate chassis, circuit and power line grounds.

CONNECTIONS:
Connections on rear; monitor outputs on front.

CONTROLLED TIMING:
Repetition Period: 100 μsec to 99.99 sec.
Signal On-Time: 10 μsec to 9.999 sec.
Transient Delay Pulse: 10 μsec to 9.999 sec.
Receiver Delay: 10 μsec to 9.999 sec.
Receiver On-Time: 10 μsec to 9.999 sec. (Note: Timing operates with or without AC signal input.)

OUTPUT CONTROL PULSES:
Sync. Output: +5 V pulse at signal turn-on followed by −5 V pulse at delayed receiver turn-on.
Signal gate output (for use with commercial E-I Normalizers): +10 V rectangular wave, having leading edge coincident with signal turn-on and lagging edge coincident with signal turn-off.
Signal transient delay output: +10 V rectangular wave having lagging edge coincident with setting of Transient Delay Control.
Receiver enable output: +10 V rectangular wave having leading edge corresponding to Receiver Delay Control, and pulse width corresponding to Receiver On-Time Control.

EXTERNAL PROGRAMMABLE FEATURE:
Parallel BCD rear panel inputs for each timing control. Remote operation on zero position of manual controls. Switch closure to ground or application of 0 to +0.8 V dc is binary one; open circuit or application of +2 to +5 V dc is binary zero. For switch closure, Model 206A produces 3.2 mA dc max. For manual setting of controls, rear connectors produce BCD outputs corresponding to control positions.

INPUT POWER:
105 - 125 V 50 - 60 Hz, 40 watts.
SIZE: 3½" high x 17" wide x 15½" deep (with hardward for mounting in standard 19" relay rack).
WEIGHT: 20 pounds; shipping, 30 pounds.

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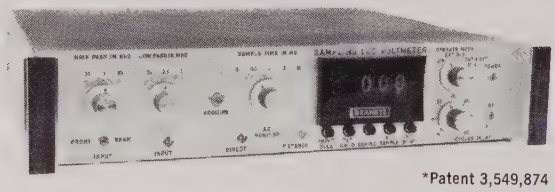
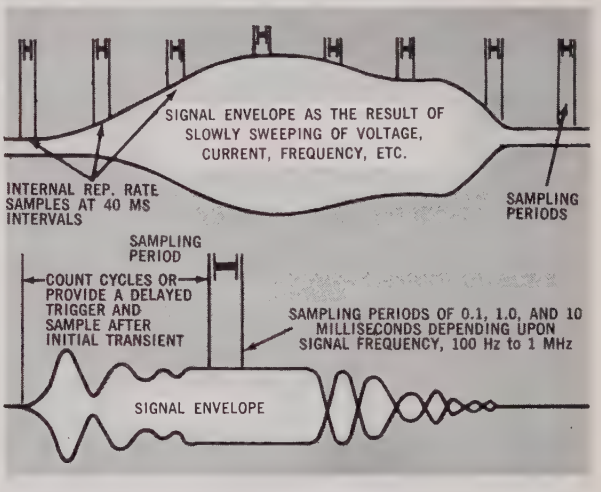
SERIES 220A

HIGH SPEED LOG SAMPLING VOLTMETER*

Direct digital readout of CW, Gated AC, or rapidly varying AC signals



*Patent 3,549,874


SIGNAL ENVELOPE AS THE RESULT OF SLOWLY SWEEPING OF VOLTAGE, CURRENT, FREQUENCY, ETC.
INTERNAL REP. RATE SAMPLES AT 40 MS INTERVALS
SAMPLING PERIODS
SAMPLING PERIOD
COUNT CYCLES OR PROVIDE A DELAYED TRIGGER AND SAMPLE AFTER INITIAL TRANSIENT
SAMPLING PERIODS OF 0.1, 1.0, AND 10 MILLISECONDS DEPENDING UPON SIGNAL FREQUENCY, 100 Hz to 1 MHz
SIGNAL ENVELOPE

FEATURES:

- Frequency range - 100 Hz to 1 MHz
- Sample and hold output - analog and digital outputs
- Single or repetitive measurement to 1000 samples per second
- Sampling times down to 100 μsec
- Output independent of sampling time or duty cycle
- 84 dB dynamic range - 300 μV to 5 V (to 5 kV with voltage probes)
- Logarithmic digital display and BCD outputs
- Complete programmability for either remotely controlled or computer controlled test systems
- Rejects unwanted signals up to 50 dB higher than desired signal

APPLICATIONS:

- High speed component testing
- Analysis of time-varying or transient effects
- Measurement of direct or reflected acoustical signals
- Measurement of signal burst levels applied to radiators or receivers.

The Model 220A Sampling Voltmeter is a gated, average responding voltmeter for measuring amplitude of AC signals during a short sampling time. Measurement can be made of rapidly varying CW signals, gated AC signals (tone bursts), or single shot AC signals. Measurements are made at any predetermined time in a selected period which can be as short as 1 cycle of the signal.

Sample and hold output circuitry, combined with internal logarithmic conversion, provide several simultaneous outputs: a digital panel meter reading directly in DBV (ref: 0 DBV = 1 V rms), a linear DC output, two logarithmic DC outputs, and a logarithmic digital output (BCD code) corresponding to the digital panel meter reading. Provision is made for insertion of an external DC signal which allows both the digital display and BCD output to correspond to other logarithmic parameters without effecting instrument calibration.

This instrument combines internal low and high pass filtering, a unique average responding detector, and logarithmic conversion to offer an exceptionally wide dynamic range, high sensitivity, wide frequency range, short sampling time and low susceptibility to noise and signal distortion compared to peak responding and rms AC instruments.

SPECIFICATIONS Model 220A

Signal Frequency Range: 100 Hz to 1 MHz.

Accuracy: ±0.3 dB to 200 kHz, ±0.5 dB 200 kHz to 1 MHz.

Resolution: Analog output - infinite Digital readout and output: 0.1 dB.

Dynamic Input Range: −70 to +14 dBV (ref. 0 dBV = 1.0 V rms) (0.3 mV to 5 V rms).

Input Circuit Configuration: Single ended, front and rear panel input jacks (BNC)

Signal Input Impedance: 1 megohm

Output Indication: (1) Digital panel meter: −70 to +14 dBV, ±199.9 dB max. indication with external DC scaling input (2) DC analog outputs, Zo = 600Ω, drives 10kΩ min. load resistance:

A. Log, 0.05 V/dB, +0.0 to +4.2 V out.

B. Log, 1 mV/dB −70.0 mV to +14.0 mV (0 V dc out ref 1 Vrms in).

C. Linear, +0.5 to +5 V dc.

(3) BCD outputs, 12 lines (8-4-2-1 BCD) TTL, DTL compatible logic

Offset Scaling: Adjustable DC offset of digital display and log output (1 mV/dB); front panel control for continuous 0 to ±100 dB offset.

Repetition Rate: Internal trigger generator approx. 10 samples/second. External trigger: 1 to 4 ms required between samples for analog DC outputs depending upon sample time; 10 msec min repetition rate for digital display and BCD outputs.

Sampling Period: Periods approx. 0.1, 0.3, 1, 3 and 10 msec. Requires min of 1 full cycle.

Filters: 0.1, 1 and 10 kHz high pass; 0.01, 0.1 and 1 MHz low pass.

Sample and Hold Facility: Output transfers from level to level without discharge. DC outputs drift less than 0.2 dB per minute after last sample. Digital output can be programmed for infinite hold.

Trigger Input (to initiate sampling): Square wave, pulse, or step, ±5 V peak, rise time < 50 μsec (10-90%) transformer input, ungrounded, input impedance approx. 5k ohms.

Delay Control to Mask Signal Transients: Below 0.5 MHz, selectable cycle count 4 to 300 cycles; above 0.5 MHz, selectable time delay of 8 to 600 μsec.

Monitor and Control Outputs: (1) Synchronizing pulses for external equipment. (2) AC monitor outputs: Filtered and unfiltered signal level approx. 2V pk-pk; filtered output has 0.5 volt pedestal indicating sampling time. (3) Fault indicating signals available at rear panel.

Visual Indicators: For overloads, correct sampling, sampling period, low and high pass filter selection, incorrect sampling and loss of signal input.

Compatibility: Compatible with Dranetz Gating/Timing Generator 206, and other pulse generators.

Programmability (rear connectors): Compatible with DTL and TTL; also operable by remote contact closures. Filter selection, sample period, timing and other functions are programmable.

AC Input Power: 115/230 V, 50-60 Hz, 35 watts

Size: 3½" high x 17" deep x 17" wide equipped for 19" rack mounting.

Weight: 25 lbs.; Shipping, 35 lbs.

DRANETZ
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SOUTH PLAINFIELD, NEW JERSEY 07080 • TEL: (201) 755-7080 • TWX: 710-997-9553

TR-SERIES SPECIAL PURPOSE INSTRUMENT TRANSFORMERS

TR-2001 3 kVA SHIELDED ISOLATION TRANSFORMER

FEATURES
- Excellent isolation between source, load and bridge
- Electrostatic shielding
- Low capacitance, low leakage inductance
- High power — 3 kVA
- Broad frequency range

APPLICATIONS
- High power bridge measurements
- Decoupling power amplifiers
- Driving reactive loads

Construction: Single shielded primary and three shielded secondary windings. Winding A has very low capacitance to shield. Winding B has moderate capacitance to shield and moderate leakage inductance. Winding C has very low leakage inductance. All shields connected to frame.

Frequency Range: $<$ 60 Hz to $>$ 25 kHz.

Maximum Power (primary): 1) Max. I: 3 Amps (rms). 2) Max. V: At 60 Hz, 130 V (rms). Increases in proportion to freq.; 1000 V (rms), 460 Hz to 25 kHz.

Impedance Loads: 5 Ω to 10 kΩ.

Winding Characteristics: 1) Primary: R $<$ 0.5 Ω, C approx. 4500 pF. 2) Secondary A (turns ratio 1:1): R $<$ 1 Ω, Cs ≈ 300 pF, L_L ≈ 0.3 mH (X_{LA} approx. 35 Ω at 20 kHz). 3) Secondary B (turns ratio 1:1): R $<$ 0.7 Ω, C ≈ 1500 pF, L_L ≈ 0.1 mH (X_{LB} approx. 13 Ω at 20 kHz). 4) Secondary C (turns ratio 2:1) R $<$ 0.3 Ω, C ≈ 2000 pF, L_L ≈ 0.06 mH (X_{LC} approx. 8 Ω at 20 kHz).

Fuse: Primary winding fused with HV fuse.

TYPICAL LOW LEVEL FREQ. RESPONSES

Secondary Winding	Load Resistance (ohms)	Freq. Range for Response Variation Less than ±0.1dB	Upper Half Power Freq. (3dB down)
A	1000	20 Hz to 50 kHz	500 kHz
C	5	20 Hz to 600 Hz	10 kHz
C	30	20 Hz to 5 kHz	70 kHz
C	100	20 Hz to 20 kHz	100 kHz

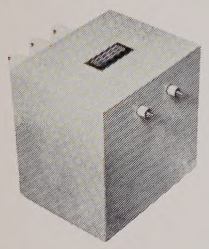
Electrical Ground: Case, frame and shields connected together.

Size: Approx. 10½″ x 11″ x 9½″ high (excluding protective fuse and carrying handle).

Connectors: Primary: Ceramic feed-throughs, 10 x 32 studs. Secondary: Female receptacle for each secondary winding, type MS 3102A-22-8S, mating MS 3106A-22-8P supplied.

Wt.: 55 lbs. approx. **Ship. Wt.:** 75 lbs. max.

TR-2003 10 kVA STEPDOWN ISOLATION TRANSFORMERS



FEATURES
- Single ended and balanced inputs
- Excellent amplitude and phase fidelity over wide frequency range
- High input impedance — low output impedance

APPLICATIONS
- Measurement of amplitude and phase of high voltage sources
- Impedance, phase and power measurements on high power electroacoustical transducers
- Testing of high voltage components such as inductors and transformers

SPECIFICATIONS
Turns Ratio: 1000: 1 ±1% at 1 kHz.

Frequency Response: Amplitude: Push-pull: ±1%, 20 Hz to 30 kHz; Single-ended: ±1%, 20 Hz to 9 kHz. Phase: Push-pull: ±2°, 20 Hz to 30 kHz; Single-ended: ±2°, 20 Hz to 9 kHz.

Primary Center Tap: Within 0.5% of true center.

Max. Input Voltage: Push-pull, CT grounded: 10 kV rms, 100 Hz to 30 kHz; Single-ended: 10 kV rms, 100 Hz to 9 kHz; Peak voltage: 15 kV, either terminal to case.

Input Impedance (Vector): Above 100 Hz, approx. 2 meg. Ω; below 100 Hz, progressively decreasing with lower freq. (approx. 1 meg. Ω at 60 Hz).

Insulation to Case: Primary: 1000 megohms; Secondary: 1000 megohms.

Internal Power Absorption: Increases as square of voltage, to less than 10 W at full voltage limit.

Load Impedance: Characteristics stated herein apply for resistive loads between 1 k ohm and 10 k ohm.

Size: Approx. 6¾″ x 5¼″ x 7″ high excluding terminals and mounting studs.

Terminals: 3 Ceramic primary, 2 ceramic sec.

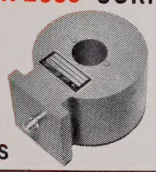
Breakdown to Case: Primary: 18 kV rms; Secondary: 1 kV rms.

Bias Current: DC bias current should not be placed through windings.

Construction: Steel encased, oil filled, mounting studs 5⅝″ x 3¼″ centers (studs ¼″ x 20″ x ⅝″ long).

Wt.: Approx. 26 lbs. **Ship. Wt.:** Approx. 32 lbs.

TR-2004 — TR-2005 CURRENT TRANSFORMERS



FEATURES
- Output voltage is faithful reproduction of input current
- Wide frequency and dynamic range
- Excellent pulse and phase response
- High voltage isolation
- 1¼″ D hole for primary

APPLICATIONS
- Testing sonar projectors and arrays
- High power immitance and transfer measurements
- Measuring transients in SCR's
- Measuring electron beam currents
- Current sensing in AC feedback systems

SPECIFICATIONS

CHARACTERISTIC	TR 2004	TR 2005
Sensitivity per Primary Turn (V rms/A rms)	0.1; +0, −1%	1.0; +0, −1%
Square Pulse Input		
Max. Current	10,000 A pk	1,000 A pk
Rise Time	For rise times $>$ 1 microsec.	40 nanosec. approx.
Droop	10^{-4}%/microsec.	10^{-2}%/microsec.
Max. Amp-sec. per pulse	1	0.1
For Sinusoidal Input		
Amplitude Limit	100 A rms above 17 Hz; 9 A pk/Hz below 17 Hz; 90 A pk at 10 Hz	10 A rms above 100 Hz; 0.15 A pk/Hz below 100 Hz; 7.5 A pk at 50 Hz
Useful Frequency Range	0.25 Hz to 700 kHz	20 Hz to 10 MHz
Amplitude Response with Frequency +0%, −1% Limits		1 kHz to 4 MHz
Low Frequencies	4 Hz to 100 kHz 3 dB at 0.25 Hz	3 dB at 20 Hz; −3% at 200 Hz; −5% at 100 Hz
High Frequencies	3 dB up to 700 kHz; +2.5% at 300 kHz; +7% at 400 kHz	3 dB at 10 MHz
Phase Response ±0.8° Limit	20 Hz to 100 kHz	1 kHz to 2 MHz
Low Frequencies	1.5° at 10 Hz; 2.9° at 5 Hz	2° at 500 Hz; 4° at 250 Hz; 8° at 100 Hz; 13° at 50 Hz
High Frequencies	1.5° at 200 kHz; 2.2° at 300 kHz	2.7° at 5 MHz
Electrostatic Shielding With 1000 volts rms at 5 kHz on primary, secondary output corresponds to less than:	10^{-4} ampere turns through primary	10^{-5} ampere turns through primary
Maximum Insertion Impedance	0.0002 ohms	0.02 ohms
Maximum Voltage	15 kV pk surface to high voltage; 30 kV pk with primary insulation	
Typical Primary Capacitance	6 pF in oil; 3 pF in air	
Recommended Load	$>$ 10,000 Ω in parallel with $<$ 20 pF	
Dimensions	(approx) 5″ OD x 1¼″ ID x 2½″ high plus mounting flange (4 mounting holes on flange: ¾″ D on centers 1¾″ x 2½″)	
Connector	BNC	
Weight	4 pounds approx.	
Shipping Weight	8 pounds approx.	

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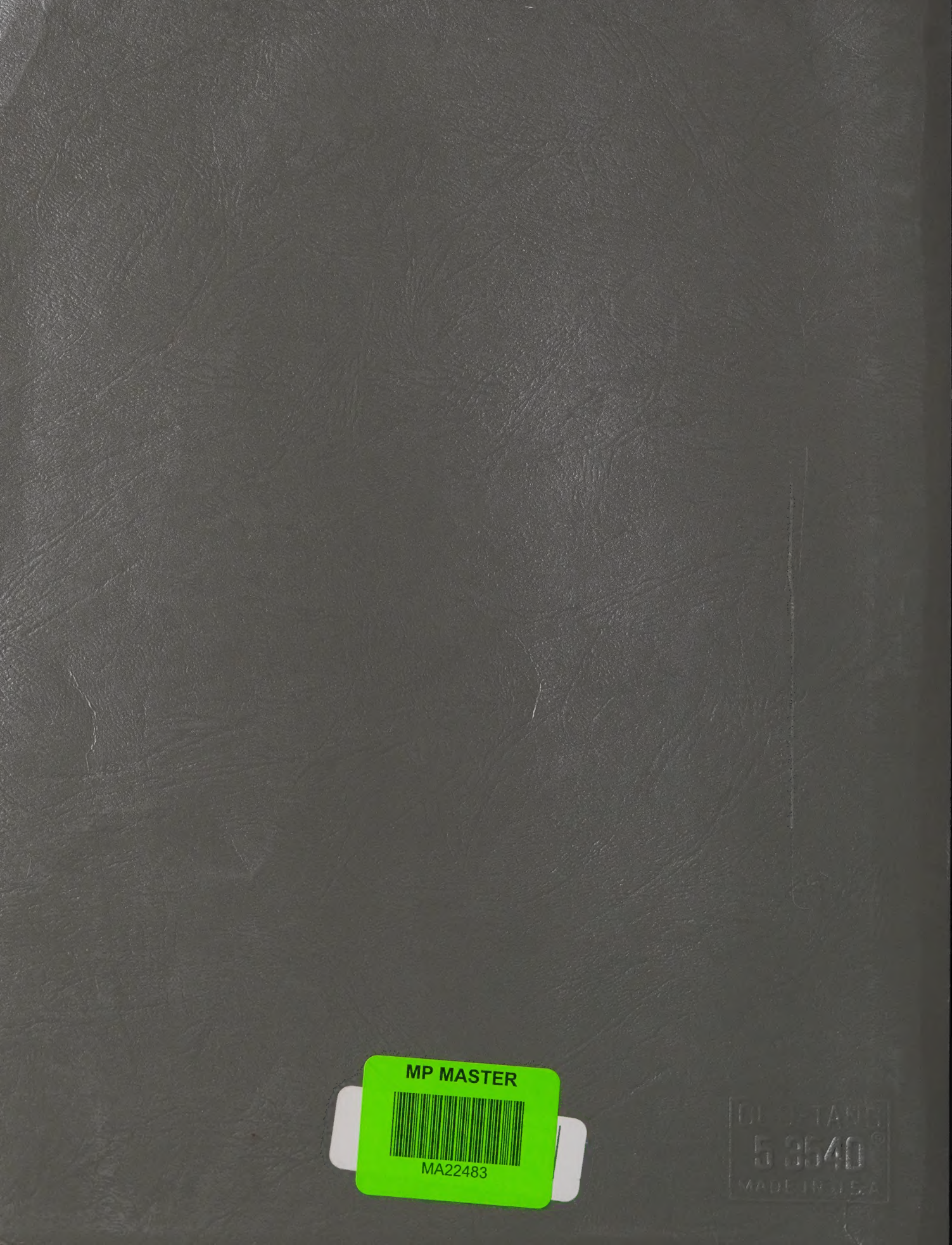
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